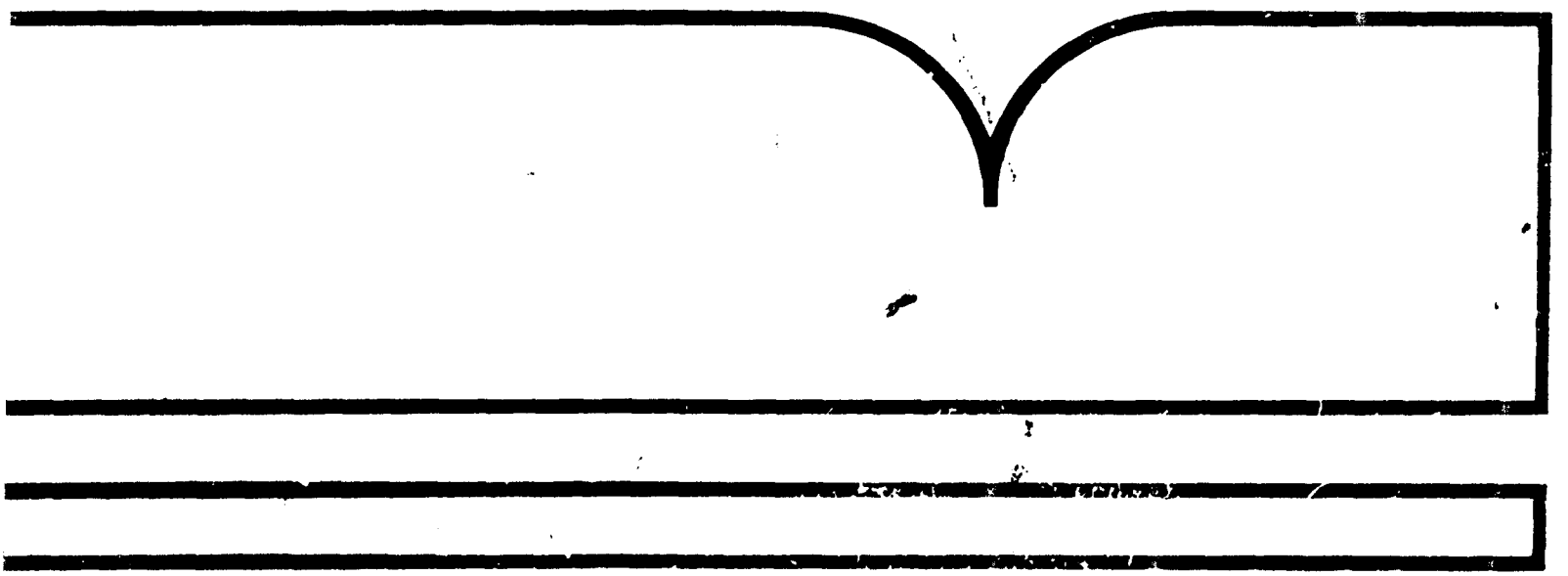
DEEPENING AND EXTENDING CHANNELS FOR NAVIGATION

Corps of Engineers
Charleston, SC

Apr 80



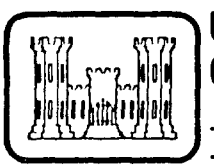
PHASE 1

CHARLESTON HARBOR

SOUTH CAROLINA

APPENDIXES

DEEPENING AND EXTENDING CHANNELS FOR NAVIGATION



United States Army
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Charleston District

APRIL 1980

PHASE 1 A E & D STUDY
CHARLESTON HARBOR
SOUTH CAROLINA

APPENDIXES

DEEPENING AND EXTENDING CHANNELS FOR NAVIGATION

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PREPARED BY THE
CHARLESTON DISTRICT, CORPS OF ENGINEERS,
DEPARTMENT OF THE ARMY

APPENDIX A

PROBLEM IDENTIFICATION

APPENDIX A
PROBLEM IDENTIFICATION

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PROBLEM IDENTIFICATION

Description of Project

PROJECT LOCATION

1. Charleston Harbor is the largest seaport in South Carolina, a major naval base and the only Polaris submarine base on the Atlantic seaboard. The harbor is located about midway along the coastline of South Carolina. The entrance to Charleston Harbor is approximately 140 statute miles southwest of the entrance to Cape Fear River, North Carolina, and 75 statute miles northeast of the Savannah River. Charleston Harbor is formed in the vicinity of the confluence of the Cooper, Ashley and Wando Rivers. It lies in the tidal estuary of the lower 12 miles of the Cooper River and the four miles of open bay between the confluence of the Ashley and Cooper Rivers and the Atlantic Ocean. The entrance to the harbor is protected by two granite jetties, 2,900 feet apart, which spring from Sullivans and Morris Islands, respectively. The harbor is approximately two miles wide between the entrance channel and the junction of Ashley and Cooper Rivers. Its location along the South Atlantic Seaboard permits ready access to European and South American ports. The harbor's size and location are incentives to recreational boating activities. In one way or another, the harbor affects the social and economic well-being of the people in the entire study area.

EXISTING PROJECT

2. The existing authorizations for Charleston Harbor provide for Navy and commercial navigation consisting of: (a) a commercial channel 35 feet deep from the Atlantic Ocean to the mouth of Goose Creek, 26.3 miles with varying widths; (b) a channel 35 feet deep and 500 feet wide through Town Creek; (c) a connection channel 10 feet deep in Shem Creek; (d) a channel 10 feet deep from Shem Creek to the Atlantic Intracoastal Waterway; (e) a 40-foot National Defense channel from the 40-foot

ocean contour to the Commandant's wharf (mile 12.6) with varying widths and an anchorage basin 30 feet deep located between Shutes Folly Island and Fort Sumter, to be prosecuted only as found necessary in the interest of national defense. All project features have been completed except for the 40-foot National Defense channel.

3. The Naval Ammunition Depot (NAD) channel extends from the head of the authorized commercial navigation project (vicinity of Goose Creek) upstream 3.48 miles. A channel for the U.S. Navy Noise Measurement Facility extends from the end of the NAD channel 1.0 miles upstream. Both of these channels have a project depth of 35 feet with varying widths.

4. The Cooper River Rediversion Project was authorized by the River and Harbor Act of 1968 with the view of substantially reducing harbor shoaling. Construction of this project will redivert to the Santee River the major portion of the fresh water originating in the Santee River Basin and currently passing through the Pinopolis Hydroelectric Power Plant into the Cooper River and Charleston Harbor. Rediversion of this freshwater flow would reduce the current average discharge of 15,600 cfs at Pinopolis to a non-damaging average of 3,000 cfs. The 3,000 cfs discharge is that flow previous investigations indicate to be a tolerable flow which will not result in harmful sediment trapping density currents.

PROBLEM IDENTIFICATION

5. The main problem which exists in Charleston Harbor is the lack of sufficient depth. Increased project depths are required to facilitate tankers, large container ships, and other larger vessels which are currently using or anticipate using the harbor in the future. Lack of depth is causing an increase in shipping costs which are passed on to the consumers of the shipped goods. These increases in price are felt throughout the state of South Carolina. Especially dependent on the port are the metropolitan areas of Charleston, Columbia, Greenville

and Spartanburg. Portions of the states of Georgia, Alabama, Mississippi, Tennessee and North Carolina are also affected. Additional land area is needed to provide for future port expansion and industrial development. Large land purchases to this end have been made by the S. C. Ports Authority. In May 1972, the SCPA purchased 500 acres of land on the Wando River for future port development. Another problem of the harbor is the unusually high rate of shoaling and associated costs incurred in maintaining project depths. The high rate of shoaling stems from various effects of the diversion of waters of the Santee River into the upper Cooper River since 1942. Construction of the Cooper River Rediversion Project is currently underway. When completed, it will alleviate much of this shoaling problem. Other port related problems include insufficient turning area for prospective traffic, inappropriate approaches to the bridges, narrow channel width in congested areas and encroachment of mooring vessels into the Federally-maintained channel.

EFFECT OF HARBOR PROBLEM

6. South Carolina's economy has expanded steadily during the last decade. Despite the continued economic growth based on the latest data contained in the "Statistical Abstract of the United States," the state still stands 48th in per capita income. It is estimated that some 1,500 firms, located in all of the state's 46 counties, regularly use the state ports system, and the 1977 value of cargoes in international trade exceeded 2½ billion dollars. Firms utilizing port facilities employ approximately two-thirds of the state's total manufacturing employment.

7. During the next 20 years it is estimated that approximately 500,000 new jobs must be created to insure adequate employment for the projected labor force. In order to meet this demand, new industry must be attracted and existing industry expanded. The Port of Charleston is considered one of the primary means by which this goal can be met. Unless needed port improvements are accomplished, the port will be placed at a competitive disadvantage with respect to other South Atlantic ports, particularly in soliciting the business of the newer, larger vessels with deeper drafts.

In time, this disadvantage will become more acute as the frequency of calling by the newer vessels increases. Eventually the port would be reduced to a second-class operation and the state's economy would suffer proportionately.

8. Even if needed port improvements are accomplished and the port continues as an active and safe harbor capable of meeting the demands made by the newer and larger vessels, several constituents must be present for it to continue fulfilling its vital role to the social well-being and economic betterment of the citizens of South Carolina. Primary among the constituents are the ability to produce a product, a market for the product, and a means of delivering the product.

9. Textile and apparel manufacturing account for about one-third of the total personal income of the Greenville and Spartanburg SMSA'S. This area is especially well suited as a distribution center, as it is located in the middle of the Piedmont Distribution Crescent, which extends from the Greensboro-Winston-Salem area in North Carolina to Atlanta, Georgia. This crescent now contains more than 6 million persons and is recognized as the largest complex in the southeast and one of the fastest growing in the nation.

Tributary Areas of Charleston Harbor

GENERAL

10. During the past decade, the economy of the South Atlantic Region has grown at a faster rate than that of the United States as a whole. The State of South Carolina, as a part of this region, has contributed to and shared in this rapid growth. State per capita personal income increased from 60 percent of the national average in 1950 to 62 percent in 1960, and to 74 percent in 1970 and is project to be 80 percent in 1974. This represents an increase in current dollars from $893 per capita in 1950 to $3,635 in 1974.

11. The growth in waterborne commerce through Charleston Harbor over the past several years reflects the rapid economic development of the South Atlantic Region and the State of South Carolina. The composition of cargo through Charleston Harbor reflects the economic base of South Carolina and its neighboring states. Imports and coastwise receipts are greater than exports and coastwise shipments and this trend is expected to continue. Major bulk imports are petroleum (residual fuel oil), farm products, chemical products, and plywood and veneer. Major coastwise receipts are petroleum and related products. The major exports consist of farm products, pulp and paper products, and textile products. Coastwise shipments represent a relatively small share, about three percent, of total traffic volume traversing the waterway.

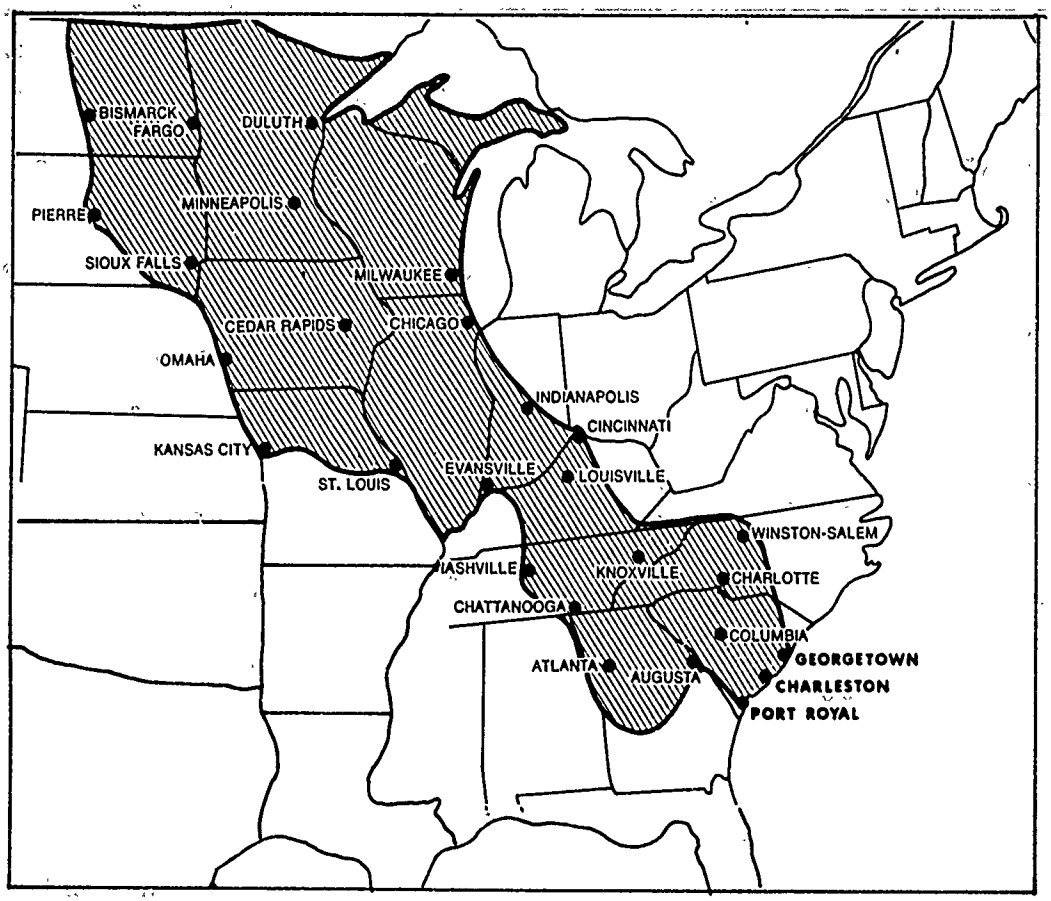
FREIGHT TRIBUTARY AREA

12. Figure A-1 indicates the general freight tributary area of Charleston Harbor. This is defined as the area in which freight rates to the port of Charleston, inland export or import class and commodity rail rates, are generally equal to, or lower than rates applying between the same points and other Atlantic Coast ports. However, the only area in which any port has rates that no other port can match is an area within about 100 miles. This is denoted as a captive rate area, because as a rule, no other port has equal inland freight rates within this area. Study[1/] of the origin and destination of general cargoes indicates that about 60 percent of the cargoes moving through the port of Charleston have their origin or destination within the state of South Carolina, with the greater portion, petroleum products excepted, moving inland over 100 miles from the port. The distribution of light petroleum products in the central and western portions of the state by the Plantation and Colonial pipelines limit the port tributary area of those products to less than 100 miles from Charleston Harbor. The tributary area for most petroleum products will generally be as outlined in Figure B-1, Appendix B, for South Carolina.

1/ Reference: An Economic Analysis of South Carolina's Ports, by David R. Pender, University of South Carolina.

GENERAL FREIGHT TRIBUTARY AREA FOR

THE PORT OF CHARLESTON, SOUTH CAROLINA



Source: S.C.Port News
June 1974

FIGURE A-1

ECONOMIC INDICATORS

13. The standard economic indicators and others found to be related to the use of Charleston Harbor are keyed to the State of South Carolina and BEA Economic Areas Nos. 28, 29, 30, and 31 (Figure A-2). These economic areas have been delineated by the Regional Economic Division, Bureau of Economic Analysis (BEA), Department of Commerce and the Economic Research Service (ERS), Department of Agriculture, who have made national and area economic projections to 2020 for the Water Resources Council. The projections dated April 1974 have been adopted as the current appraisal of the long-range national trends for planning purposes. These projections are designated as "OBERS Projections." Thirty-five of the forty-six South Carolina counties are included in BEA Economic Areas 28, 29, 30 and 31, which are considered as representative of the general cargo tributary area of the Port of Charleston. Various combinations of these areas would be representative of the various petroleum products tributary area.

Existing Economic Conditions

GENERAL

14. The following paragraphs discuss the existing economic condition of the state of South Carolina and of BEA areas 28, 29, 30 and 31 (Figure A-2). The commerce moving through Charleston Harbor is primarily determined by the economy of the state and these areas, though some commerce does originate or have its destination beyond the state boundaries.

POPULATION

15. The 1977 population of the State of South Carolina was 2,876,000, an increase of 11.0 percent over its 1970 population, slightly more than

SOUTH CAROLINA
Counties, County Seats, Mountains, and Rivers

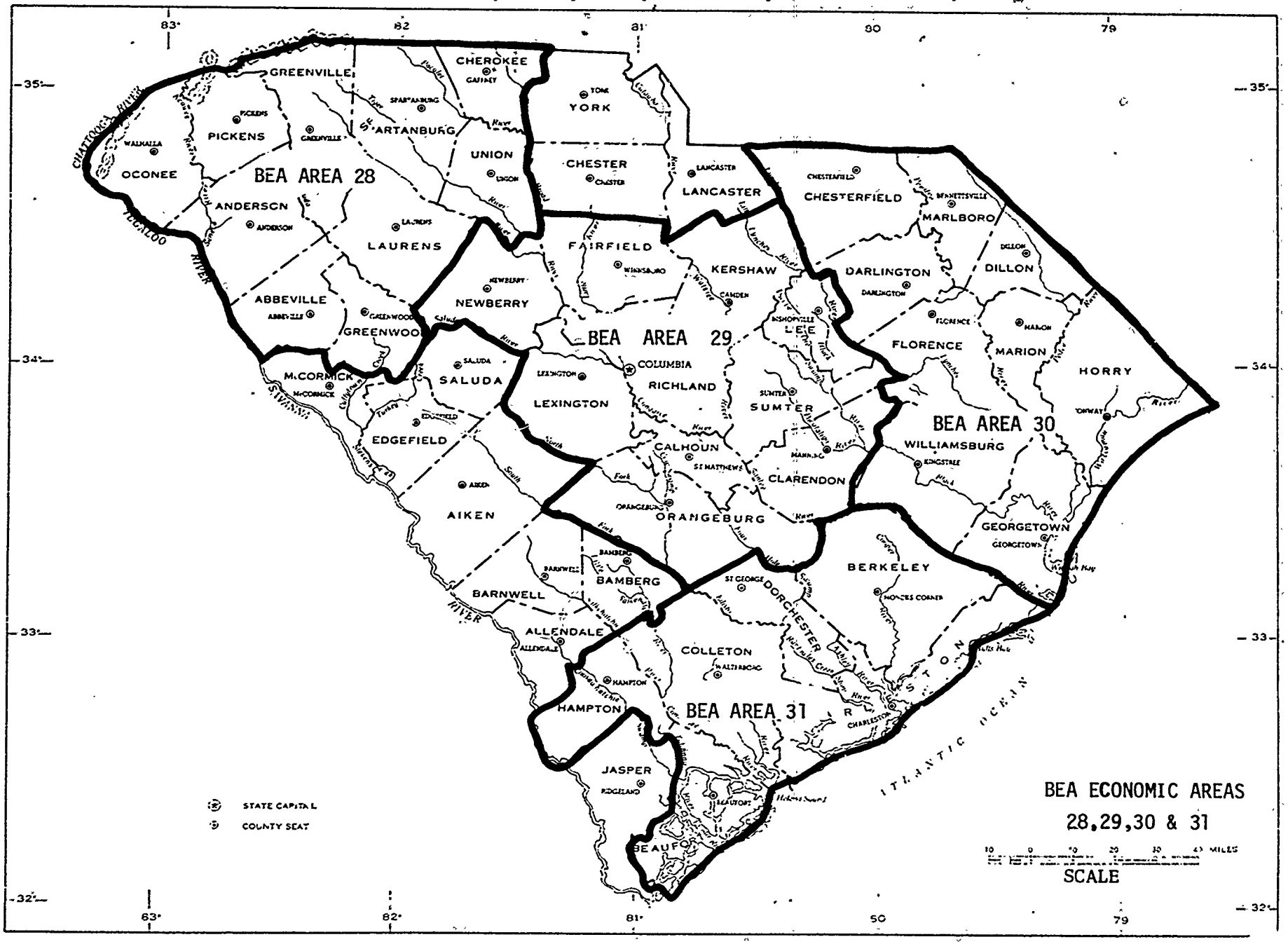


FIGURE A-2

the 8.7 percent increase registered during the 1960-1970 decade. BEA Economic Areas 28, 29, 30 and 31, with 1976 populations of 887,500, 672,000, 442,900, and 487,400, respectively, registered changes over their 1970 populations of 8.3, 8.0, 10.3, and 12.9 percent, respectively. About 47.6 percent of the state's 1970 population resided in urban areas as compared with only 41.2 percent of the 1960 population.

INCOME

16. The total personal income of residents living in the state of South Carolina amounted to about $16,186 million in 1977 and averaged $5,628 per capita, in current dollars, or about 79 percent of the national average. This represents an increase of about 22 percent in real per capita income over 1970 as compared with about 16 percent for the nation as a whole. The per capita income of BEA Areas 28, 29, 30 and 31 generally parallel that of the state as a whole.

EMPLOYMENT

17. The average annual employment in the state in 1977 totaled 1,188,000 with 7.2 percent of the labor force unemployed. About 379,900 persons or about 32.0 percent were employed in manufacturing activities, 212,000 or about 17.8 percent were employed in government, 141,800 or 16.7 percent were employed in wholesale and retail trade, and the remainder were either self-employed or in contract construction, agriculture, transportation, communication, utilities, finance, insurance, real estate, unpaid family workers, or domestics. Selected 1977 employment data for the state and the BEA Areas are tabulated in Table A-1.

TABLE A-1

WORK FORCE ESTIMATES [1]
1977

	Unit	State of S. C.	OBE Economic Area 28	29	30	31	Total OBE Areas
Civilian Work Force	Persons	1,280,000	390,590	300,430	205,300	185,030	1,081,350
Unemployment	Percent	7.2	6.6	6.7	8.7	7.7	7.2
Employment	Persons	1,188,000	364,810	280,370	187,450	170,700	1,003,330
Agriculture [2]	Persons	111,100 [3]	12,700	50,000	3,870	12,650	79,220
Manufacturing	Persons	379,900	162,660	60,480	54,030	23,890	301,060
Contract Construction	Persons	65,900	19,320	15,420	7,230	11,920	53,890
Transportation, Communications & Utilities	Persons	45,200	13,680	11,280	5,710	8,700	39,370
Government	Persons	212,000	44,930	68,280	24,370	48,790	186,320
Wholesale & Retail Trade	Persons	198,800	60,790	49,190	30,740	33,790	174,510
Finance, Ins. & Real Estate	Persons	41,200	11,110	14,450	4,680	7,100	37,340
Services [4]	Persons	133,900	39,620	32,040	21,920	23,910	117,490

Source: South Carolina's Manpower in Industry

1/ Employment by establishment or place of work bases.
2/ Includes non-agricultural self employed, unpaid family, domestic workers and mining.
3/ Approximately 46,000 were employed in agriculture.
4/ Included in services are those services related to agriculture, forestry and fisheries as well as the wide range of services to individuals and business establishments.

INDUSTRIAL DEVELOPMENT

18. The types of industry within the state of South Carolina are many and varied. Industry has expanded greatly in recent years. Manufacturing accounted for about 32 percent of the employment in the state in 1977 and construction accounted for about six percent. The major industries are textiles, chemicals and allied products, non-electrical machinery, food and kindred products, electrical equipment and supplies, stone, clay, glass, and paper and allied products. As an indication of the industrial development in the state, the "value added by manufacture" has increased by a factor of 2.5 in constant dollars during the period 1954 to 1967 and by a factor of 1.64 during the 1967 to 1972 period. This trend is expected to continue.

AGRICULTURE

19. Agriculture plays an important role in the economy of the state. The value of crop production in 1974 was over $546 million. However, the number of farms has decreased from 54,248 in 1964 to 29,275 in 1974 and the land in farms has decreased from 8,101,450 acres in 1964 to 6,177,000 acres in 1974. To partially offset this decrease in the number of farms and total acreage in farm lands, average farm size has increased from 144 acres in 1964 to 211 in 1974. The continued disappearance of the smaller marginal farms along with the appearance of larger units resulting from mergers to realize more efficient operations contribute most to the change in farm numbers and the increase in the average size of farms. Urbanization and highway construction account for much of the decline of total acreage devoted to farming. Leading crops in value of production are tobacco, soybeans, corn, cotton, peaches, hay, truck crops and small grains.

TRANSPORTATION FACILITIES

20. An excellent network of Interstate, U.S., state and local highways, railroads, and airlines adequately connect the population centers of the state with the port at Charleston and with all metropolitan and other centers in the nation. A collector system of highways provides adequately for suburban transportation and also provides for farm-to-market needs.

MINERAL RESOURCES

21. The mineral resources of the state are varied; a large number of mineral materials have been produced. The principal products now producted are kaolin, clays, vermiculite, crushed stone, monumental stone, sand, gravel, and cement. Other minerals mined are barite, feldspar, kyanite, scrap-mica, and peat.

FOREST RESOURCES

22. Little of the virgin stands of pines and hardwoods which once covered the state remain. Much of the area that was once cleared and cultivated has been allowed to revert to forests. The major species in the state consists of slash pine in the southeastern corner of the state, longleaf and loblolly pines in the midlands, and shortleaf and virgin pines in the mountains. Supplementing the pines are the hardwoods of the river swamps and the mountains. Most important of these hardwoods are the sweet gum, black gum, oak, and yellow poplar. Almost 12 million acres or about 62 percent of the total state area are classified as commercial forests by the U.S. Department of Agriculture, Forest Service.

Measures of Economic Growth

GENERAL

23. The economic activity of a region is influenced by the course of the nation's economy. The same basic forces which cause national or regional growth affect the economic activity of a state in various degrees. The projections for the State of South Carolina and the BEA Economic Areas are tied to national and regional economic activity through the use of broad measures of gross national product, personal income, employment, number of households, and population. Allowances were made for certain variant tendencies observable in the past in their relationship of the state to regional and national totals.

24. The projections of future economic growth should not be considered conclusive, but are designed to serve as guides for future planning. They could be expected to prevail, at least for the near future, under conditions of generally full employment, no major wars or depressions, and a reasonable expanding economy. The following paragraphs discuss the significance of the economic indicators which are developed in the projected economic development section which follows.

PERSONAL INCOME

25. Personal income is one of the most comprehensive measures of economic activity that can be prepared on a regional basis. It provides a yardstick for measuring the past growth and future potential of an area. The basic reason for personal income being such a comprehensive measure of economic activity is that over the past decades, personal income has grown nationally at about the same rate as the gross national product, which is a more precise measure of economic growth. It is generally not available on a less-than-national basis, whereas personal income data are generally available on a state and county basis. The projections of personal income for the State of South Carolina and the BEA Economic Areas are keyed to national projections.

EMPLOYMENT AND POPULATION

26. Employment data which are used to measure economic opportunities have been based on industry-by-industry and area-by-area appraisals of differential growth rates related to national averages. Since employment is a measure of the number of persons engaged in economic activity, employment projections are directly related to the increases in the national product and the output per worker. The population of an area is controlled by two basic forces. The first of these is the natural increase (net increase of births over deaths), and the second force is net migration. When the number of job opportunities lags behind the size of the labor force, there is an out-migration; conversely, when job opportunities lead the size of the labor force, there is an in-migration. During short-term periods, there may be fluctuations where the level of economic activity may either lead or lag the population growth. However, over an extended period of several decades, the population growth of an area will generally follow the national and regional trend.

VALUE ADDED BY MANUFACTURE

27. The "value by manufacture" is obtained by subtracting the cost of raw materials, parts, components, supplies, fuels, goods purchased for resale, and contract work from the value of shipments and adjusting for the net change in finished work-in-process inventory. It is a measure of the extent to which the manufacturing process enhances the value of materials used in production. Value added by manufacture is a measure of industrial activity, which in turn influences the activities of Charleston Harbor as well as the nation as a whole.

HOUSEHOLDS

28. The number of households in an area is directly related to population and per capita income. An increase in per capita income would bring with it an increase in the standard of living and would permit more families to have their own separate dwellings rather than living under crowded conditions with other families or adult children with parent or older persons with their children. Inasmuch as the household is a basic unit of consumption of various goods and services, the number of households in an area may also be used as an indicator of demand for such things as land, water supply, services, and various goods.

Project Economic Development

GENERAL

29. The projections for future years are based on the fundamental assumption that the forces which have produced our expanding national economy in the past will continue to exert a similar influence in the future. The national output in the past 50 years has increased at an average rate of about three percent per year, and it is predicted that during future years the nation should do even better. Therefore, the estimates of future growth are based on the relationship fundamentally derived from an analysis of past economic trends and then modified to compensate for the anticipated changes in economic development.

30. It is not possible, of course, to foresee a full range of economic developments and changes which may modify the trends significantly. New production techniques may produce results beyond those embodied in our calculations, and the introduction of new goods and services may have a compounding effect on demand beyond that implied in our projections. During the past three decades, such changes have had significant effects, and this supports the assumption that the state's output will tend to accelerate in the coming years. All the projections presented herein are consistent with this assumption.

NATIONAL TRENDS

31. The estimates of the long-term projections of economic development for the nation, the state, and BEA Economic Areas 28, 29, 30, and 31, as discussed in the following paragraphs, are the OBERS projections made for the Water Resources Council.

32. The past rate of progress in the United States' economy has been considerable and impressive. The projections shown in Table A-2 present a summary of future growth that can be reasonably expected. All of the projections are based upon the assumption of a high level of employment and activity, no major depressions or wars, and a continuation of the current, relative needs of the civilian economy and the national defense.

Gross National Product and Personal Income

33. The expected growth of the gross national product and personal income is based on a compounded average annual increase of 4.1 and 4.2 percent, respectively. This growth of national output and income is expected to result from the increasing population and labor force and the anticipated increased output per worker from technical improvements of machines, skills, methods, and organization. The results of this growth will be reflected by an increased standard of living. Gross national product and personal income, on a per capita basis, are projected by dividing the projected total values by the corresponding projected population estimates.

POPULATION

34. The population growth for the United States during the past two decades, as well as the anticipated growth for the next 60 years, is shown in Table A-2. From 1900 to 1950, the national annual growth rate averaged 1.4 percent. During the next 20 years, this growth rate increased to an average of 1.5 percent annually. The population projections for the period 1970 to 2030, as shown in Table A-2, are based on an average annual growth rate of about 0.8 percent.

LABOR FORCE

35. The labor force of the United States grew from a yearly average of 63,900,000 persons in 1950 to 99,500,000 in 1977. The size of the future labor force is estimated to increase at a slightly greater annual growth rate than that of the population during the period 1970-2030. According to the new U. S. Bureau of Labor statistics, this force is comprised of all persons willing and able to work and 16 years old and over. However, many source materials have only partially been converted to the new definition. Therefore, for the OBERS projections in this appendix, the old "14 years old and over" concept is used throughout. Projected data are shown in Table A-2.

EMPLOYMENT

36. Employment in the United States grew from a yearly average of 58,900,000 persons in 1950 to 99,500,000 in 1977. National employment is projected on the basis of full employment, which is assumed to exist when no more than four percent of the national labor force is unemployed. Projected data are shown in Table A-2.

TABLE A-2

SUMMARY OF NATIONAL PROJECTIONS

Item	Units	Actual				Projections				Average Annual Percent Increase 1970-2030
		1950 [1]	1960 [2]	1970 [2]	1977 [2]	1980 [3]	2000 [3]	2020 [3]	2030 [4]	
Population of the United States	Millions	151.9	180.0	203.8	216.8	223.5	263.8	297.1	334.6	0.8
Labor Force	Millions	63.9	72.1	85.9	99.5	100.1	122.8	135.9	153.3	1.0
Employment	Millions	58.9	65.8	78.6	90.5	96.1	117.9	130.5	147.2	1.0
Gross National Product										
Total	Billions, 1967	425.7	588.0[5]	858.1[5]	1,066.9[5]	1,266.5	2,439.9	4,323.9	5,500.0	3.7
Per Worker	Dollars, 1967	7,228.0	8,936.0[5]	10,917.0[5]	11,789.0[5]	12,652.0	19,869.0	31,817.0	35,877.0	
Per Capita	Dollars, 1967	2,807.0	3,254.0[5]	4,188.0[5]	6,167.0[5]	4,700.0	8,100.0	13,200.0		
Personal Income										
Total	Billions, 1967	313.6	450.5[5]	689.1[5]	837.8[5]	1,068.5	2,154.3	3,931.9		3.5[6]
Per Capita	Dollars, 1967	2,068.0	2,493.0[5]	3,363.0[5]	3,904.0[5]	4,700.0	8,100.0	13,200.0		
Number of Households	Millions	42.9	53.0	63.4	74.1	74.2	93.9	113.8		
Number per Household	Persons	3.52	3.38[5]	3.20[5]	2.86[5]	3.01[5]	2.81	2.61		

1/ "Statistical Abstract of the United States, 1976" (97th edition) 1976, U. S. Bureau of the Census.
2/ "Statistical Abstract of the United States, 1978" (99th edition) 1978, U. S. Bureau of the Census.
3/ "1972 OBERS Projections, Regional Economic Activity in the U. S., Series E Population," 1972, U. S. Water Resources Council, Washington, D. C.
4/ Estimated by Charleston District.
5/ Derived from data in above cited "Statistical Abstract of the U. S., 1978"
6/ Average Annual Percent Increase, 1970-2020.

HOUSEHOLDS

37. In the past 30 years, the average number of persons per household in the United States has shown a considerable decline. Accordingly, the number of households has shown a greater rise than total population. The influences which have led to the reduction in the size of households may have largely spent their force, especially in the "undoubling" which has taken place in the past several years, following the general consolidation of households which occurred both in the depression years before World War II and during and immediately after the war. For the long-term national projections, the number of households is expected to increase at a slightly greater annual growth rate than the total population or approximately 1.8 percent.

SOUTH CAROLINA TRENDS

38. The broad, general assumptions used in estimating state projections are similar to those used in estimating national projections and are shown in Table A-3.

POPULATION

39. The population of South Carolina has grown from 1,340,316 in 1900 to 2,876,000 in 1977, which indicates an annual growth rate of 1.0 percent. Projections shown in Table A-3 are based on the estimate that the past annual growth rate will decrease slightly through 2030.

LABOR FORCE AND EMPLOYMENT

40. Total employment for the State of South Carolina was about 41 percent of the total population in 1977, in comparison with the national average of about 41.7 percent in 1977. The national is projected to

TABLE A-3

SUMMARY OF SOUTH CAROLINA PROJECTIONS

Item	Units	Actual				Projections				Average Annual Percent Increase 1970-2030
		1950 [1]	1960 [2]	1970 [2]	1977 [2]	1980 [3]	2000 [3]	2020 [3]	2030 [4]	
Total Population	Thousands	2,113.0	2,382.6	2,590.5	2,876.0	3,000.9	3,537.2	3,864.4	3,910.0	0.7
Percent of U. S.		1.4	1.3	1.3	1.3	1.3	1.3	1.3		
Total Employment	Thousands	771.5	803.7	951.0	1,188.0	1,313.7	1,593.7	1,710.3	1,725.0	1.0
Employment/Population Ratio		.37	.34[5]	.37[5]	.41[5]	.44	.45	.44	.44	
Personal Income										
Total	Millions, 1967	2,609.8	3,764.0[5]	6,594.0[5]	8,918.0[5]	11,041.0	23,260.0	42,929.0		
Per Capita	1967 Dollars	1,235.0	1,573.0[5]	2,538.0[5]	3,101.0[5]	3,679.0	6,576.0	11,109.0		
Percent of U. S.		.60	.63	.75	.79	.78	.81	.84		
Number of Households	Thousands	514.6	603.6	734.4	915.0	912.1	1,144.7	1,337.2	1,401.4	1.1
Number per Household	Persons	4.1	3.8	3.39	3.14[5]	3.29	3.09	2.89	2.79	

1/ "1972 OBERS Projections, Regional Economic Activity in the U. S., Series E Population," 1972, U. S. Water Resources Council, Washington, D. C.
2/ "South Carolina Statistical Abstract, 1978," 1978, South Carolina Division of Research and Statistical Services, Columbia, South Carolina.
3/ "Summary of Projections, Economic Activities in the Southeastern States, Series E Population," October, 1976, U. S. Army Corps of Engineers, South Atlantic Division, Atlanta, Georgia.
4/ Estimated by Charleston District.
5/ Derived from data contained in above "South Carolina Statistical Abstract"

increase to about 44 percent in 2020. The state average is projected to level off at about 44 percent. This in effect reflects an average annual increase of 1.0 percent from 1970 to 2030. State employment is projected on the basis of full employment, which is assumed to exist when no more than four percent of the state labor force is unemployed. Projected data are shown in Table A-3.

Gross State Product and Personal Income

GENERAL

41. In lieu of an evaluation and projection of the gross state product for which basic data are not available, personal income is used as the primary measure of economic activity for South Carolina. On a per capita basis, the personal income of South Carolina has lagged the national value for the past several decades, but has an upward trend in relation to the national value in the past two decades. Industrialization has been increasing rapidly, however, which has resulted in a relatively high rate of growth in per capita personal income in recent years. The projections for the total personal income for the state of South Carolina are based on the assumption that the state's per capita income would increase to 84 percent of the nation's average by the year 2020. This would reflect an average annual growth rate of about 2.9 percent for per capita income and 3.7 percent for total personal income for the time period 1970 to 2020.

HOUSEHOLDS

42. The number of households in South Carolina increased from about 514,600 in 1950 to about 915,000 in 1977, reflecting an average annual growth rate of about 2.1 percent. Because of the relatively high density of population and the relatively larger size household (3.1 persons per household as compared to 2.9 for the United States), the average-size household in the state is expected to decrease to about the national average. This projection is further strengthened by the expectation of a greater relative increase in personal income per capita for South Carolina as compared to the United States.

BEA ECONOMIC AREA TRENDS

43. The broad, general assumptions used in estimating BEA area projections are similar to those used in estimating national projections. Actual data for 1950-1976 and projected data for 1980-2030 for BEA Economic Areas 28, 29, 30 and 31 (Figure A-2) are shown in Table A-4.

POPULATION

44. The combined 1976 population of the four considered Economic Areas (Figure A-2) was 2,489,800 or about 87.4 percent of the population of the state of South Carolina. This represents a 22.2 percent increase in population over 1959 for the BEA Economic Areas as compared to a 21.3 percent increase for the state and a 19.3 percent increase for the United States (1960-1976). A summary of actual population, 1950-1976, and a projected population to 2030 for each of the areas is shown in Table A-4.

LABOR FORCE AND EMPLOYMENT

45. The labor force for the four BEA areas was about 41 percent of their total population in 1976, about the same as for the state. Employment

TABLE A-4

SUMMARY OF COUNTIES WITHIN BEA ECONOMIC AREAS 28, 29, 30 AND 31

ITEM	UNITS	ACTUAL				PROJECTIONS (OBERS) Series E			
		1950 [1]	1959 [1,2]	1970 [1]	1976 [3]	1980 [1]	2000 [1]	2020 [1]	2030 [4]
Population (mid-year)									
BEA Area 28	Thousands	676.0	730.5	819.4	887.5	949.1	1,172.8	1,336.5	1,415.0
" " 29	"	468.3	543.6	622.1	672.0	677.2	835.8	946.5	1,000.0
" " 30	"	396.4	400.3	401.6	442.9	436.7	491.4	513.3	500.0
" " 31	"	290.4	363.0	431.7	487.4	407.7	447.5	486.7	507.0
TOTAL		1,831.1	2,037.4	2,274.8	2,489.8	2,470.7	2,947.5	3,283.0	3,442.0
Percent of U. S.		1.2	1.2	1.1		1.1	1.1	1.1	
Total Employment									
BEA Area 28	Thousands	264.0	292.5	346.3	396.0	436.0	548.7	604.6	620.0
" " 29	"	164.9	198.8	244.8	275.5	297.5	378.9	422.4	435.0
" " 30	"	135.8	129.7	144.3	185.3	176.3	207.3	216.8	215.0
" " 31	"	102.1	128.0	166.8	162.6	173.3	196.5	213.3	215.0
TOTAL		666.8	751.0	902.2	1,019.4	1,083.1	1,331.5	1,457.1	1,488.0
Total Personal Income									
BEA Area 28	1967 Millions	973.5	1,218.9	2,309.3	2,790.1 [5]	3,734.9	8,129.3	15,383.1	17,600.0
" " 29	"	546.8	811.5	1,616.9	2,101.1	2,432.6	5,418.3	10,446.2	12,200.0
" " 30	"	358.1	476.6	903.8	1,178.5	1,434.4	2,957.5	5,308.8	6,200.0
" " 31	"	394.8	570.6	1,160.1	1,486.1	1,557.7	3,026.1	5,582.6	6,300.0
TOTAL		2,273.2	3,077.6	5,990.1	7,555.8	9,159.6	19,531.2	36,720.7	42,300.0
Per Capita Income									
BEA AREA 28	1967 Dollars	1,440.0	1,669.0	2,818.0	3,144.0	3.935.0	6,932.0	11,510.0	12,438.0
" " 29	"	1,168.0	1,493.0	2,599.0	3,127.0	3,592.0	6,483.0	11,037.0	12,200.0
" " 30	"	903.0	1,191.0	2,251.0	2,661.0	3,285.0	6,018.0	10,342.0	11,923.0
" " 31		1,359.0	1,572.0	2,588.0	3,049.0	3.801.0	6,762.0	11,470.0	12,426.0
AVG. TOTAL AREA		1,241.0	1,511.0	2,633.0	3,035.0	3,707.0	6,626.0	11,185.0	12,289.0
Percent of U. S.		60		76		79	82	85	

NOTES: 1/ "Projections, Economic Activity in South Carolina, Series E Population," December 1975 and "Projections, Economic Activity in North Carolina, Series E Population," April 1976, U. S. Army Corps of Engineers, South Atlantic Division, Altanta, Georgia.

2/ Employment is for 1960.

3/ "South Carolina Statistical Abstract, 1978" 1979, South Carolina Division of Research and Statistical Service and "Profile, North Carolina Counties, Update" 1978. Department of Administration, Division of State Budget and Management, Research and Planning Services, Raleigh, North Carolina.

4/ Estimated by Charleston District.

5/ North Carolina portion is for 1975.

is projected on the same basis as for the state and the nation, full employment which is assumed to exist when no more than four percent of the area's labor force is unemployed. Projected data are shown in Table A-4.

PERSONAL INCOME

46. According to the basic measure of personal income, the economy of the four areas is about equal to that of the state as a whole. Based on anticipated future conditions, it is expected that the annual growth rate of personal per capita income for the areas will average 2.7 percent annually and increase to over 82 percent of the United States average per capita income during the 1970-2030 period.

Historical Commerce

GENERAL

47. At the time this study was made, the last statistics on commerce were contained in the Corps of Engineers' publication "Waterborne Commerce of the United States" for calendar year 1977. In 1977, a total of 10,527,659 short tons of waterborne commerce moved over the Charleston Harbor waterway. Oceangoing vessels transported 86.5 percent (9,107,465 short tons) of the total commerce. The remaining 13.5 percent (1,420,194 short tons) reflects the commerce moved by barge traffic mainly over the Atlantic Intracoastal Waterway or between points within the harbor. Charleston Harbor commerce for 1958 through 1977 is tabulated in Table A-5. During the 20-year period from 1958 through 1977, oceangoing commerce increased at the compound rate of about 4.4 percent, and total waterborne commerce also increased at a compound rate of about 4.4 percent per year.

TABLE A-5

CHARLESTON HARBOR COMMERCE
1958-1977 1/

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Year	Total Commerce Tons 2/	Total Commerce 3/	Foreign		Domestic				Local
					Coastwise		Internal		
			Imports	Exports	Receipts	Shipments	Receipts	Shipments	
1958	4,351,361	4,344,731	1,336,975	258,187	2,059,557	178,800	60,288	357,075	100,479
1959	4,636,653	4,624,095	1,492,842	254,842	2,104,175	252,799	63,786	338,652	123,421
1960	4,974,962	4,960,913	1,346,462	471,485	2,399,406	219,089	82,940	311,789	110,869
1961	5,016,729	5,010,732	1,401,148	476,809	2,274,573	150,711	48,654	389,617	235,761
1962	5,055,512	5,052,920	1,319,480	391,573	2,522,651	245,267	141,330	208,285	224,148
1963	5,295,002	5,274,917	1,529,301	491,219	2,539,511	272,735	74,873	203,971	112,207
1964	5,106,523	5,097,456	1,520,714	609,969	2,404,377	289,836	100,158	147,318	5,181
1965	4,950,395	4,936,917	1,404,134	535,594	2,343,945	28,855	96,389	352,136	189,342
1966	5,419,919	5,393,930	2,140,767	650,708	2,308,758	44,256	50,463	120,354	104,613
1967	5,564,620	5,545,426	1,709,380	919,678	2,623,171	74,973	115,359	54,245	67,814
1968	6,390,459	6,369,469	2,102,625	915,421	2,777,399	96,501	231,214	106,380	160,919
1969	6,043,725	6,021,573	1,979,856	650,721	2,707,942	129,426	245,680	231,227	98,873
1970	6,874,993	6,849,325	2,592,562	694,418	2,939,274	147,578	182,194	230,160	88,807
1971	6,945,951	6,928,336	2,706,070	733,066	2,949,371	232,641	65,235	189,141	70,427
1972	7,476,635	7,463,159	3,347,868	767,051	2,840,139	244,803	56,345	159,976	60,453
1973	9,379,766	9,370,869	3,780,754	1,070,655	3,281,199	306,796	141,225	685,836	113,301
1974	8,992,563	8,919,531	3,112,711	1,302,072	3,076,500	388,058	207,882	796,814	108,526
1975	8,379,831	8,377,677	2,824,929	1,369,728	2,900,365	333,700	147,192	677,726	126,191
1976	9,664,865	9,664,865	2,939,473	1,806,653	3,384,698	393,314	189,855	808,921	141,951
1977	10,327,659	10,327,659	3,460,242	1,552,595	3,777,410	317,218	194,629	783,969	241,596

NOTES: 1/ Source; "Waterborne Commerce of the United States, Part One, 1958-1977.
2/ Total Commerce Excluding Through Traffic
3/ Total Commerce Less Ashley River Traffic.

48. Oceangoing commerce is divided into two groups: foreign (which includes imports and exports) and coastwise. In 1977, 5,012,837 short tons of foreign commerce and 4,094,628 short tons of coastwise commerce passed through Charleston Harbor. These figures represent compound rates of increase of about 5.8 and 3.0 percent, respectively, over the 1958 tonnages, illustrating the rapid growth of foreign commerce compared to the coastwise commerce.

49. Some commodity groupings have historically constituted the majority of the waterborne commerce in the harbor. Table A-6 is a twenty-year summary of the five largest commerce-producing groups. Over the last decade or so, these have accounted for 80 to 90 percent of the total. Since 1960, this percentage has somewhat stabilized at close to 80 percent. Seventeen commodities, thirteen of which are contained in one of the four major commerce groupings, produced 100,000 short tons or more commerce in 1977 with the exception of kerosene and are classified as major commodities. A tabulation of these commodities for the study period is presented in Table A-7 and discussed below with their respective commodity group.

Major Commodities

PETROLEUM AND RELATED PRODUCTS

50. Since 1960, petroleum and related products have been the largest single commerce producer, contributing from 60 to 80 percent of the total commerce. There has been a noticeable downward trend in the percentage which petroleum products contribute to the total commerce. From 1965 to 1977, this percentage has averaged 63.8 percent. Gasoline and residual fuel oil are the leading products, with distillate

TABLE A-6

SUMMARY OF MAJOR COMMODITIES

Year	Total Commerce C.M.	Total Commerce 1/	Foreign		Domestic				
					Coastwise		Internal		Local
			Imports	Exports	Receipts	Shipments 2/	Receipts	Shipments	
PETROLEUM AND RELATED PRODUCTS 1958-1977									
1958	3,495,806	3,495,806	938,850	823	1,967,071	168,106	2,320	319,546	99,090
1959	3,599,941	3,599,941	940,079	640	1,908,262	233,745	2,531	310,868	122,262
1960	3,808,899	3,804,670	878,885	28	2,288,145	207,737	-	297,913	110,866
1961	3,749,540	3,744,116	794,387	1	2,161,334	133,738	1,235	384,398	235,564
1962	3,762,958	3,763,958	669,677	234	2,421,351	239,093	18,829	190,072	222,884
1963	3,797,591	3,797,591	840,422	-	2,410,917	257,453	1,046	172,750	110,772
1964	3,440,607	3,440,607	793,097	29	2,246,913	270,989	10,155	114,727	4,697
1965	3,286,075	3,286,075	596,098	71	2,148,179	13,977	32,874	316,347	178,529
1966	3,429,913	3,419,616	1,088,231	13	2,474,462	1,261	5,427	92,515	97,674
1967	3,242,137	3,242,137	708,889	19	2,428,646	7,024	19,662	21,020	56,867
1968	3,742,196	3,739,879	947,936	88	2,592,927	1,787	28,115	62,081	109,262
1969	3,947,198	3,947,918	1,072,019	94	2,529,652	28,415	30,665	190,140	96,215
1970	4,698,518	4,698,518	1,558,272	43	2,789,557	41,295	28,924	199,948	80,478
1971	4,458,397	4,458,008	1,342,908	3905	2,785,169	59,611	45,699	156,730	64,346
1972	4,601,308	4,587,832	1,742,710	1237	2,594,026	45,566	40,731	116,582	60,453
1973	6,269,460	6,269,460	2,390,665	816	3,040,489	9,069	77,687	644,430	106,304
1974	5,907,668	5,907,668	2,078,895	716	2,887,243	50,873	66,314	751,006	72,694
1975	5,353,601	5,353,601	1,680,850	1703	2,843,750	25,131	44,475	634,407	124,272
1976	5,890,571	5,890,571	1,602,729	1703	3,250,806	33,568	84,950	774,979	141,846
1977	6,707,339	6,709,339	1,956,912	4438	3,646,383	35,813	71,887	752,906	341,300
FARM PRODUCTS 1958-1977									
1958	140,226	140,226	102,788	30,103	-	78	-	-	-
1959	111,398	111,398	98,137	13,147	-	42	-	-	-
1960	127,970	127,970	112,554	20,035	1	201	-	-	-
1961	125,394	125,394	112,893	12,475	-	26	-	-	-
1962	135,190	135,190	121,083	14,162	-	75	-	-	-
1963	225,235	225,235	100,688	108,883	-	11,229	-	2,847	-
1964	255,873	255,873	63,520	171,605	-	9,363	-	-	-
1965	346,118	346,118	154,626	177,181	-	11,299	-	3,012	-
1966	446,287	446,287	148,312	284,441	146	13,388	-	-	-
1967	657,575	657,575	146,802	486,862	65	23,846	-	-	-
1968	464,448	464,448	119,169	320,379	37	24,863	-	-	-
1969	360,443	360,443	154,088	186,997	206	17,844	-	1,308	-
1970	221,359	221,359	123,965	95,611	106	1,677	-	-	-
1971	360,962	360,962	223,508	125,048	420	2,159	-	9,827	-
1972	315,541	315,541	149,948	161,810	1,850	2,286	-	147	-
1973	399,812	399,812	137,748	257,820	668	3,576	-	-	-
1974	521,427	521,427	174,968	323,310	139	16,251	-	6,759	-
1975	553,479	553,479	148,524	400,586	39	3,963	-	376	-
1976	783,999	783,999	215,635	563,484	267	4,173	440	-	-
1977	510,824	510,824	189,784	314,313	174	6,555	-	-	-
PULP AND PAPER PRODUCTS 1958-1977									
1958	95,279	95,279	5,955	65,303	-	491	-	23,530	-
1959	106,268	106,268	5,613	75,345	-	12,567	-	12,743	-
1960	205,314	205,314	7,827	189,979	-	6,180	-	4,328	-
1961	222,604	222,604	6,472	210,361	-	3,724	-	2,047	-
1962	148,497	148,497	11,835	131,395	-	124	-	5,143	-
1963	169,637	169,637	15,871	145,876	-	1	-	7,889	-
1964	219,330	219,330	24,780	168,007	-	-	19,113	7,430	-
1965	235,529	235,454	83,902	148,414	2	243	-	10,968	-
1966	177,952	177,952	37,251	123,208	433	7,645	-	9,415	-
1967	265,275	269,275	33,543	214,223	899	5,021	-	11,589	-
1968	320,171	320,171	28,210	277,188	34	4,608	-	10,131	-
1969	259,541	259,540	45,173	199,327	97	5,479	-	9,465	-
1970	361,086	361,086	30,915	313,796	383	8,238	-	7,754	-
1971	385,776	385,776	48,251	303,731	241	26,076	-	7,457	-
1972	307,476	307,476	35,414	219,735	342	36,605	131	15,621	
1973	297,975	297,975	30,879	222,290	812	42,531	1,097	366	-
1974	376,125	376,125	16,321	301,792	200	35,948	7,269	14,595	-
1975	400,056	400,056	19.750	318,616	297	46,428	11,457	3,508	-
1976	454,247	454,247	40,237	350,272	753	51,854	10,450	681	-
1977	532.594	532.594	81.612	404.750	545	-	-	-	-

TABLE A-6 (Cont'd.)

SUMMARY OF MAJOR COMMODITIES

Year	Total Commerce C.M.	Total Commerce 1/	Foreign		Domestic				
					Coastwise		Internal		Local
			Imports	Exports	Receipts	Shipments	Receipts	Shipments	
CHEMICAL PRODUCTS 1958-1977 5/									
1958	213,566	208,267	197,869	13,856	70,790	67	15,265	-	-
1959	244,496	239,098	131,494	8,971	82,337	412	15,784	-	-
1960	240,820	231,000	97,059	10,381	87,006	262	38,515	-	-
1961	267,076	266,503	142,736	12,207	84,150	6,120	21,290	933	2
1962	276,081	276,081	150,392	14,610	96,754	59	14,265	-	-
1963	267,381	258,966	128,901	17,037	84,573	1,822	26,612	-	-
1964	279,608	278,384	121,375	13,189	108,655	131	35,988	-	-
1965	373,859	363,076	175,700	19,442	131,198	31	32,255	6,835	8,398
1966	305,470	294,816	156,827	28,029	109,352	1,061	6,041	-	4,160
1967	270,604	253,334	90,861	25,865	131,806	2,006	9,299	-	10,947
1968	408,688	397,885	171,418	74,141	152,028	3,278	3,000	-	4,823
1969	237,540	222,738	57,093	48,524	119,399	6,724	3,140	-	2,660
1970	279,223	264,875	114,848	77,403	68,721	8,802	1,120	-	8,329
1971	321,286	310,389	147,178	68,235	76,752	14,548	8,492	-	6,081
1972	365.236	365,236	111,639	103,747	122,541	23,419	2,000	1,890	-
1973	407,188	398,291	124,938	159,073	89,077	24,714	1,938	451	6,997
1974	532,097	459,065	126,661	261,060	40,326	31,018	37,200	-	35,832
1975	304,143	302,224	61,306	220,950	1,234	15,324	-	3,410	1,919
1976	355,306	355,306	48,626	196,356	53,517	54,868	1,501	438	-
1977	409,176	409,176	125,472	192,880	50,248	29,842	-	2,310	-
ORES AND CONCENTRATES 1958-1977 6/									
1958	55,491	55,491	55,033	457	1	-	-	-	-
1959	80,305	80,305	78,971	1,446	-	78	-	-	-
1960	70,750	70,750	48,061	18,074	-	-	3,481	1,134	-
1961	N.A.	N.A.	N.A.	N.A.					
1962	88,225	88,225	83,766	3,555	-	-	-	904	-
1963	160,284	160,284	143,697	2,283	-	-	10,593	3,711	-
1964	N.A.	N.A.	N.A.	N.A.					
1965	136,353	136,353	136,277	76	-	-	-	-	-
1966	229,921	229,921	227,643	78	-	-	2,200	-	-
1967	243,410	243,410	243,410	-	-	-	-	-	-
1968	237,257	237,257	236,684	573	-	-	-	-	-
1969	183,469	183,469	171,691	11,778	-	-	-	-	-
1970	328,259	328,259	323,780	4,479	-	-	-	-	-
1971	269,524	269,524	244,285	25,239	-	-	-	-	-
1972	288,747	288,747	288,701	46	-	-	-	-	-
1973	223,855	223,855	159,339	26,735	-	-	37,781	-	-
1974	158,963	158,963	103,076	298	5,566	-	50,023	-	-
1975	504,048	504,048	430,916	10,845	-	-	61,164	1,123	-
1976	433,676	433,676	342,810	15,683	14,821	-	60,362	-	-
1977	510,024	510,224	356,521	81,309	-	22	70,006	1,240	-

NOTES: 1/ Total Commerce Less Ashley River Traffic

2/ Waterborne Commerce Code No. 29

3/ Waterborne Commerce Code No. 01

4/ Waterborne Commerce Code No. 26

5/ Waterborne Commerce Code No. 28

6/ Waterborne Commerce Code No. 10

N.A. Not Available

fuel oil, asphalt, jet fuel, lubricating oils and kerosene accounting for significant commerce. These products, exclusive of kerosene, represented 6 of the 17 major commodities in 1977 and have historically been leading commodities. Since 1964, crude oil has not been brought to Charleston; however, the loss of this commerce has been offset by increased movement of other petroleum products.

CHEMICAL AND ALLIED PRODUCTS

51. In 1977, chemical products were the fifth leading tonnage group, accounting for 409,176 tons or 4.0 percent of the total commerce. The main items are sodium hydroxide, crude tar, basic chemicals and products, plastic materials, synthetic fibers, and fertilizer and fertilizer materials. The chemical tonnage has increased at a compound rate of about 3.45 percent since 1958.

FARM PRODUCTS

52. The third leading commerce producer in 1977 was farm products, totaling about 4.9 percent of the total commerce. Since 1958, the compound growth rate has been 7.0 percent, making it one of the faster growing tonnage groups. The leading products are soybeans, corn, bananas and animal products, which collectively accounted for about 89 percent of the total farm commerce in 1977. Since the completion of the grain elevator in 1963, soybeans have become one of the leading farm products.

PULP AND PAPER PRODUCTS

53. The recent rapid growth of pulp and paper products (a compound growth rate of about 5.7 percent since 1960) have moved this commodity

grouping into second place in 1977, which indicates a more influential role in Charleston Harbor commerce. In 1977, this group accounted for 5.2 percent of the total commerce. The leading exports are pulp, paper and paperboard, while the leading import is standard newsprint paper.

ORE AND ORE CONCENTRATES

54. Since 1963, this product group has shown a consistently high rate of commerce activity as well as a fairly consistent pattern of increasing usage of Charleston Harbor. This group in 1977 was the fourth largest producer of commerce and accounted for about 4.9 percent of the total tonnage. Between 1960 and 1977 growth was at the rapid rate of 13.1 percent per year, the fastest rate of any of the major groups.

OTHER MAJOR COMMODITIES

55. All but two of the major commodities shown in Table A-6 were included in the five major commodity groups as discussed above. These commodities are in order of 1977 tonnage: basic textile products (159,210) and veneer and plywood (149,900). The compound rate of growth for these two commodities is about 4.3 and 12.3 percent, respectively, since 1960. Veneers and plywood are expected to have a significant role in the future commerce of Charleston Harbor, along with the continuing important part played by the basic textile industry.

REMAINING COMMERCE

56. Since 1960, the total tonnage of commodities not included in the 14 major commodities shown in Table A-7 have represented from 16 to

TABLE A- 7

MAJOR COMMODITIES

Item	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
Residual Fuel Oil	964,596	465,977	807,355	907,694	563,343	1,052,843	750,664	1,112,625	1,070,592	1,298,136
Gasoline	1,173,966	692,007	1,094,540	1,114,188	1,073,605	1,109,550	1,093,459	978,231	1,037,817	1,207,881
Distillate Fuel Oil	561,236	308,200	750,541	709,363	654,321	409,552	366,212	426,818	320,705	438,953
Asphalt	45,218	153,740	88,324	46,515	99,630	534,232	462,915	323,545	350,959	397,562
Jet Fuel	174,758	93,206	163,002	126,781	254,776	300,960	241,875	291,188	220,426	266,768
Lubricating Oils	80,808	31,263	108,058	125,123	122,095	167,047	161,852	144,197	147,264	168,752
Kerosene	262,203	217,682	201,190	191,584	145,166	98,347	92,306	92,306	83,308	94,196
Chrome Ores	53,737	103,042	79,312	150,341	208,548	120,878	215,421	237,174	211,914	164,207
Soybeans	195	--	28	44,757	80,309	241,959	341,986	197,682	139,493	142,940
Bananas	74,903	--	79,993	64,978	48,262	59,455	89,470	75,933	88,876	118,633
Paper & Paperboard	--	--	19,641	28,665	32,315	116,361	81,011	76,537	68,163	114,751
Veneer & Plywood	19,111	10,713	28.323	35,986	51,820	197,423	68,574	97,199	51,644	101,802
Pulp	158,234	183,997	94,839	105,756	120,650	67,843	61,501	146,401	158,299	87,078
Basic Textile Products	76,794	66,878	90,855	87,200	88,001	53,102	83,950	83,950	82,478	99,430

Item	1970	1971	1972	1973	1974	1975	1976	1977
Residual Fuel Oil	1,827,978	1,568,119	1,870,744	3,091,226	3,062,038	2,651,859	3,094,902	3,592,540
Gasoline	1,234,619	1,248,279	1,329,689	1,410,733	1,343,721	1,414,398	1,432,132	1,560,433
Distillate Fuel Oil	495,872	504,776	524,595	660,491	503,195	487,913	533,870	592,410
Asphalt	429,327	422,508	304,105	410,325	439,085	354,593	288,967	337,313
Jet Fuel	253,624	367,769	197,509	271,949	136,308	171,329	188,092	270,101
Lubricating Oils	151,221	141,543	163,767	192,350	219,118	156,155	179,917	185,417
Kerosene	215,420	117,314	135,162	136,878	125,012	66,026	81,502	66,385
Chrome Ores	294,337	228,422	270,977	168,554	141,359	464,790	386,225	433,596
Soybeans	94,280	91,479	89,111	170,432	127,217	122,516	130,897	155,710
Bananas	88,683	189,980	123,662	122,611	156,182	129,422	173,634	167,426
Paper & Paperboard	155,595	281,250	163,458	145,097	156,023	132,793	171,073	199,239
Veneer & Plywood	110,158	145,333	212,425	193,479	146,240	121,313	145,635	149,900
Pulp	167,606	127,820	90,835	96,931	186,524	230,104	255,838	299,525
Basic Textile Products	106,811	133,096	206,909	221,617	226,740	147,055	204,811	159,210

SOURCE: Waterborne Commerce of the United States - Part I - 1960-1977.

30 percent of the oceangoing commerce and averaging about 24.7 percent. This grouping is composed of individual commodities whose yearly tonnage is generally less than 100,000 tons. In recent years, however, corn tonnage has exceeded this by a substantial margin.

Selected Indicators

GENERAL

57. Transportation needs are generated by the economic and social activities of people and their demands for goods and services. By an analysis of these demands, how they have been satisfied in the past, foreseeable parameters of socio-economic activity and foreseeable constraints, an estimate may be made of future quantities and modes of transportation required. Therefore, estimates of the future tonnage Charleston Harbor will be required to handle reflects the needs of an increasing population in a changing world. To determine the approximate economic indicators of future traffic, consideration was given to the use of commodities being transporated and the magnitude of the market area assigned to the merchantable commerce. During the past few years, energy supplies, especially petroleum products, have played a pivotal role in business decisions and governmental policies affecting economic levels of activity and commerce. The United States Department of Energy was founded in response to the need for coordination in data gathering and policy formulation due to problems that had manifested themselves in the early 1970's through shortages in petroleum products supplies in 1972 and the oil embargo in 1973. The world-wide inflations, recessions, and other economic dislocations which have become prevalent during this time have caused changes in plans for future commerce that will be felt to an increasing extent well past the year 2000. Indicators which have been utilized for future commerce include: Population projections for the tributary area for petroleum products, Energy Policy and Conservation Act

mandated fuel economy standards for passenger cars manufactured after 1977, individual industry sectors' own plans for energy use, Energy Information Administration information, projections of manufacturing activity by the Bureau of Economic Analysis of the U.S. Department of Commerce for the South Atlantic Division of the U.S. Army Corps of Engineers, projections of economic activities in other applicable sectors, and sustainable yields in forestry products. Several of these indicators and intermediate points determining changing ranges of growth are summarized in Table A-8.

CONCEPT

58. In the selection of indicators of future tonnage, the following guidelines were used:

(1) 1974 OBERS projections as detailed for South Carolina in "Projections, Economic Activity in South Carolina, Series E Population," December 1975, by the Bureau of Economic Analysis, U.S. Department of Commerce for the U.S. Army Corps of Engineers, South Atlantic Division.

(2) Indicators were chosen as closely related to the commodity being moved as possible.

(3) Indicators reflected the future demand for the commodities to which they were applied.

(4) Modifications to indicators were made when justified by local developments to where in-depth studies concerning a particular commodity were available for the commodity market area.

(5) Data, projections and methodologies were checked with those used in other studies in order to insure comparability in the market area of Charleston Harbor.

(6) Historical trends were utilized where available and applicable to project Charleston Harbor commerce.

TABLE A-8

ECONOMIC INDICATORS APPLICABLE TO CHARLESTON HARBOR TRIBUTARY AREA

INDICATOR	UNIT	1960	1970	1974	1985	1995	2005	2015	2025	2035
Petroleum Tributary Area:										
Population	Thousands		976.7		1,152.8	1,215.0	1,250.0	1,268.0	1,290.0	1,315.0
Food & Kindred Products Production	Millions $67		59.8		92.0	115.5	141.0	166.5	189.0	205.0
Textile Mill Production	Millions $67		95.4		201.5	289.0	392.0	500.0	590.0	645.0
Chemicals & Allied Products Production	Millions $67		65.3		181.0	305.0	473.0	670.0	855.0	988.0
Lumber & Furniture Production	Millions $67		80.6		125.5	166.5	212.5	260.5	301.0	325.0
Non-metallic Mining, Except Fuels, Earnings	Millions $67		0.8		1.7	2.4	3.0	3.5	3.9	4.0
State of South Carolina:										
Textile Mill Production			1,289.7		2,100.0	2,610.0	3,440.0	4,480.0	4,780.0	5,200.0
Chemicals & Allied Products Production	Millions $67		518.2		1,280.0	2,030.0	3,030.0	4,280.0	5,540.0	6,550.0
Timber Production	Percent			100.0	121.0	148.0	183.0	225.0	277.0	340.0
Agricultural Earnings	Millions $67		196.7		219.0	240.5	269.5	302.5	342.0	391.5
Primary Metals Production	Millions $67		26.5		55.4	67.8	79.4	93.0	106.0	120.5
Lumber Products & Furniture Production	Millions $67		118.5		210.0	277.5	357.5	442.5	521.0	578.0

SELECTED COMMODITIES

59. Based on the past historical demand for commodities and the economic activity of the area, the following commodities or commodity groupings were selected for projection: Petroleum products, oil and grain crops, veneer and plywood, chemicals, chrome ores and aluminum concentrates, wood pulp, and paper and paperboard. The petroleum products category was further broken down into the following subcategories for projection purposes: gasoline, residual fuel oil, distillate fuel oil, and other. The remaining commerce was grouped together and projected using one composite indicator. The rationale used in projecting these commodities is discussed in Appendix B.

60. A summary of projections for the commodity groups cited above appears in Table A-9. The five-year average was used as a general base. However, data for years prior to 1972 and subsequent to 1976 was also incorporated. Details concerning petroleum products, grain and ores projections are given in Appendix B. In Table A-10 the growth factors are given in summary form. Comparing veneer and plywood, woodpulp and paper and paperboard projections in Table A-9 with timber production and lumber products and furniture production economic indicators given in Table A-8 indicates a more rapid growth during the next few years than might have been expected had static bases been used exclusively. Over the entire life of the project, on the other hand, the projected tonnages are well within these general guidelines. The Other Commodities commodity group is seen to be a rapidly growing category and is projected to continue this rapid growth. This is largely a result of containerization and is explained more fully in Appendix B.

TABLE A-9

PROJECTED TONNAGES FOR SELECTED YEARS DURING LIFE OF PROJECT
(OCEANGOING COMMERCE)
(IN SHORT TONS)

COMMODITY GROUP	1960	1970	1974[1/]	1985	1995	2005	2015	2025	2035
Chemicals	233,223	269,774	374,079	463,800	542,600	663,200	783,800	890,100	992,500
Chrome Ore and Aluminum Concentrate	55,691	328,259	263,789	803,600	892,400	977,100	1,078,000	1,170,900	1,279,000
Grain	-	94,280	335,289	460,000	460,000	460,000	460,000	460,000	460,000
Petroleum Products	3,374,795	4,389,168	4,220,999	5,474,500	6,381,700	7,824,800	7,856,800	7,874,800	7,921,800
Veneer and Plywood	19,111	110,158	163,818	235,000	336,000	410,000	485,000	555,000	620,000
Woodpulp	158,121	167,606	174,023	445,000	645,000	820,000	960,000	1,060,000	1,130,000
Paper and Paperboard	20,879	147,841	148,293	300,000	418,000	520,000	582,000	633,000	660,000
Other Commodities	574,622	866,746	1,578,706	2,650,000	3,600,000	4,600,000	5,600,000	6,650,000	7,700,000
TOTAL	4,436,422	6,373,832	7,258,996	10,831,900	13,275,700	16,275,100	17,805,600	19,293,800	20,763,300

[1/] Base for projection purposes. Five-year average, 1972-1976, except for petroleum products which was projected by detailed components.

TABLE A-10

PROJECTED GROWTH FACTORS FOR SELECTED YEARS DURING LIFE OF PROJECT
(OCEANGOING COMMERCE)
(IN PERCENT)

COMMODITY GROUP	1974	1985	1995	2005	2015	2025	2035
Chemicals	81	100	117	143	169	192	214
Ores	33	100	111	122	134	146	159
Grain	73	100	100	100	100	100	100
Petroleum Products	77	100	117	143	144	144	145
Veneer and Plywood	70	100	143	174	206	236	264
Woodpulp	39	100	145	184	216	238	254
Paper and Paperboard	49	100	139	173	194	211	220
Other Commodities	60	100	136	174	211	251	290
TOTAL	67	100	122	150	164	178	192

APPENDIX B

ECONOMIC ANALYSIS

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APPENDIX B

ECONOMIC ANALYSIS

Introduction

1. The benefits that would accrue from the implementation of improvements considered in this report are derived from savings in transportation costs. The transportation savings are the difference between the transportation costs for commerce movements over the existing waterway depth and increased waterway depths being considered. Benefits were derived from reduced average cost per ton of transportation of commerce carried in tankers, containers and bulk carrier fleets over improved conditions compared to the average cost per ton of commerce carried in these fleets over existing conditions. General cargo vessels were not included in this study, because generally, those vessels operate with loaded drafts of less than 31 feet and can navigate the existing waterway without difficulty. There is at this time no indication that this will change in the foreseeable future. No national defense benefits were claimed although various bend easing and channel widening will be beneficial to the various naval vessels navigating the waterway.

Tanker Benefits

PETROLEUM AND PETROLEUM PRODUCTS PROJECTIONS

2. Since 1960, petroleum and related products have been the largest single commerce producer, contributing from 61 to 80 percent of the total commerce. There has been a noticeable downward trend in the percentage which petroleum products contribute to the total commerce.

From 1965 to 1977 this percentage has averaged 63.8 percent. Gasoline and residual fuel oil are the leading products, with distillate fuel oil, asphalt, jet fuel, lubricating oils and kerosene accounting for significant commerce. These products represented 7 of the 15 major commodities in 1977 and have historically been leading commodities. Since 1964, crude oil has not been brought into Charleston Harbor, however the loss of this commerce has been offset by increased movement of other petroleum products. Total commerce of petroleum products from 1960 to 1977 is shown on Table B-1.

3. Future commerce in petroleum products by subcategories was first projected to the base year 1985 and then by 10-year increments to 2035, the 50-year project life. The first thing to note is the recent series of shocks to the national and world economy from shortages of specific products, the oil embargo, and the subsequent dramatic price increases. There are currently no cut-and-dry comprehensive formulas presented which adequately deal with all of the economic ramifications of these problems. In as much as future usage patterns of all types of energy, not only petroleum, are subject to change, the following projections are subject to further refinement as policies and technologies change. The following projections were made after careful examination of past commerce trends, data from several Federal and State agencies, and information furnished by knowledgeable industrial users. A tributary distribution area for all petroleum products transferred over port facilities was established by contacting the local oil terminals during the 1974 Charleston Harbor study and this same tributary area was adhered to for this study. See Figure B-1 for details. Detailed projections for the various subcategories, along with methodologies and indicators, are given below.

TABLE B-1

PETROLEUM PRODUCTS
1960-1977

Item	1960	1961	1962	1963	1964	1965	1966	1967	1968
Residual Fuel Oil	964,596	465,977	807,355	907,694	563,343	1,070,592	1,112,625	750,664	1,070,592
Gasoline	1,173,966	692,007	1,094,540	1,114,188	1,073,605	1,037,817	978,231	1,093,459	1,037,817
Distillate Fuel Oil	561,236	308,200	750,541	709,363	654,321	320,705	426,818	366,212	320,705
Asphalt	45,218	153,740	88,324	46,515	99,630	350,959	323,545	462,915	350,959
Jet Fuel	174,758	93,206	163,002	126,781	254,776	220,426	291,188	241,875	220,426
Lubricating Oils	80,808	31,263	108,058	125,123	122,095	147,264	144,197	161,852	147,264
Kerosene	262,203	217,682	201,190	191,584	145,166	98,377	92,306	92,306	83,308
Other Petroleum Prod.	566,114	421,110	549,948	576,343	527,671	39,965	72,854	61,003	
TOTAL	3,808,899	3,749,540	3,762,958	3,797,591	3,440,607	3,286,075	3,242,137	3,429,913	3,742,196

Item	1969	1970	1971	1972	1973	1974	1975	1976	1977
Residual Fuel Oil	1,298,136	1,827,978	1,568,119	1,870,744	3,091,226	3,062,038	2,651,859	3,094,902	3,592,540
Gasoline	1,207,881	1,234,619	1,248,279	1,329,689	1,410,733	1,343,721	1,414,398	1,432,132	1,560,433
Distillate Fuel Oil	438,953	495,872	504,776	524,595	660,491	503,195	487,913	533,870	592,410
Asphalt	397,562	429,327	422,508	304,105	410,325	439,085	354,593	288,967	337,313
Jet Fuel	266,768	253,624	376,769	197,509	271,949	136,308	171,329	188,092	270,101
Lubricating Oils	168,752	151,221	141,543	163,767	192,350	219,118	156,155	179,917	185,417
Kerosene	94,196	215,420	117,314	135,162	136,878	125,012	66,026	81,502	66,385
Other Petroleum Prod.	74,950	90,457	88,089	75,737	95,508	79,191	51,328	91,189	104,740
TOTAL	3,947,198	4,688,518	4,458,397	4,601,308	6,269,460	5,907,668	5,353,601	5,890,571	6,709,339

SOUTH CAROLINA
Counties, County Seats, Mountains, and Rivers

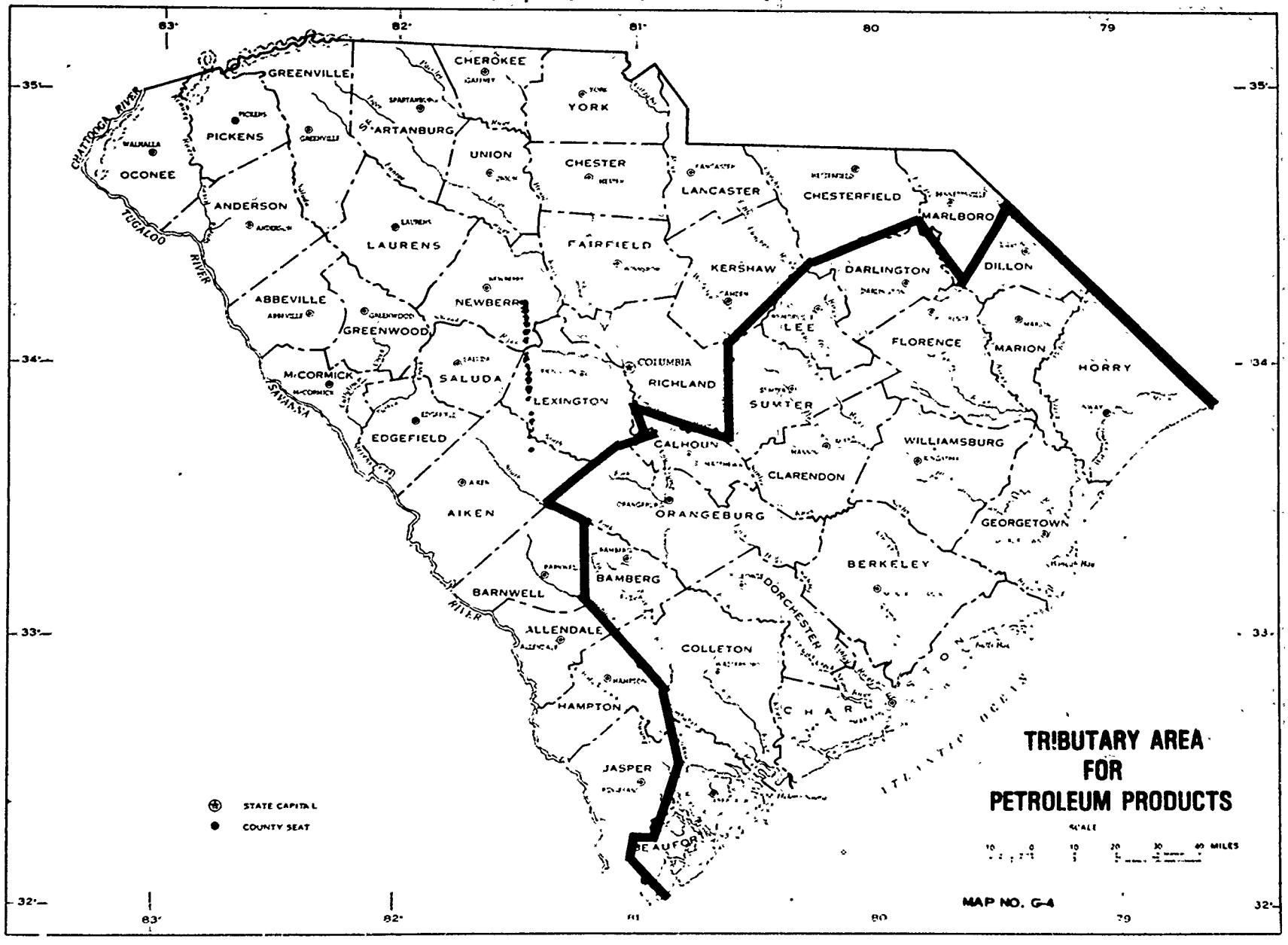

FIGURE B-1

(a) Gasoline imports in the past have been directly traceable to gasoline demand within the 18-county area. Historically, about 78 percent of the imported gasoline tonnage could be directly traced to usage by the passenger cars, buses and trucks registered within the tributary area with another 5 percent traceable to use on farms. It is assumed that the relationship between passenger car, truck and bus usage and gasoline imports will remain into the foreseeable future. Future demands for gasoline were projected by projecting numbers of vehicles in the tributary area, miles travelled, and miles per gallon obtained. Analysis of historic relationships between licensed drivers and population and licensed drivers and passenger cars registered revealed the relationship of about 57 percent of the total population holding drivers licenses and a relationship of about 86 passenger car registrations per 100 licensed drivers. In deriving estimates of future drivers, it was assumed that by 1985 some 60 percent of the population will have drivers licenses and that this percentage will remain constant throughout the project period. It was assumed, based on increasing levels of per capita income, that by 1985, the ratio of passenger car registrations per 100 licensed drivers will increase to 90 and will remain constant for the 1985-2035 period. From "Motor Vehicle Facts and Figures '77" published by the Motor Vehicles Manufacturers Association of the United States, Inc., data was obtained on average miles driven, miles per gallon of gasoline, and average age of vehicles during various periods of time from 1940 through 1976. The average annual miles travelled per passenger car has ranged from 9,020 miles in 1950 to 9,992 miles in 1973. For projection purposes, the 1973-1975 average of 9,691 miles was rounded to 9,690 and applied to the entire 1985-2035 period. From the above cited publication, it was determined that the average passenger car was slightly over six years old. In Volume II, 1977, "Annual Report to Congress", published by the

Energy Information Administration, the miles per gallon established for new cars by the Energy Policy and Conservation Act are published on page 117, with corrections on accompanying errata sheet. The following tabulation gives the referenced data; sales weighted by manufacturers:

Model Year	Miles Per Gallon
1978	18.0
1979	19.0
1980	20.0
1981	22.0
1982	24.0
1983	26.0
1984	27.0
1985	27.5

By combining the latest average age of passenger cars of six years with the above mileage standards, it was estimated that in 1985 the average car would average about 19 miles per gallon; in 1990, 27.0 miles per gallon; and 27.5 miles per gallon in subsequent time frames. The above factors were then combined to determine total gallons of gasoline demand per year for the 1985-2035 period. This was then divided by 352.56 to derive tons per year of demand. Projections of demand generated by trucks and buses were based on first trending the past in-

creases in truck and bus registrations into the future by using historical increases as a guide but decreasing the rate of growth to about 0.66 percent per year from the 1970-1976 average of about 7.7 percent per year. During this period, passenger vehicles increased at a rate of about 6.1 percent per year. This was done when a graphical analysis of trends in both passenger car registrations and trucks and buses since 1970 show similar shaped curves and it seemed reasonable to assume generally similar relationships to prevail in the future. Thus, from 1980 on, the slope of this curve was decreased to more nearly conform with the projected rate of increase of about 0.4 percent per year for automobiles. Average miles travelled per year by trucks and buses has fluctuated, but an average figure of 10,670 miles per year was used for purposes of making these projections. Lacking any definite authority as a reference to future miles per gallon to be attained by trucks and buses, the preliminary 1976 average of 8.6 miles per gallon was increased to 9.0 miles per gallon by 1985 and held constant for the 1985-2035 period. The projections of passenger car and trucks and buses gasoline demands were totalled and then multiplied by a factor of 1.28, as explained above, in order to obtain the total projected gasoline imports through Charleston Harbor for the 1985-2035 period. Details are presented in Table B-2.

(b) Residual fuel oil projections were made after studies had been made to determine present and probable future users of this petroleum product. Residual fuel oil is used in the boilers of such plants as electric utilities, paper and paperboard processors, and textile and checmical products. In a 1977 study by S. D. Sinclair,

TABLE B-2

DETAILED COMPUTATIONS FOR GASOLINE COMPONENT
OF PETROLEUM PROJECTIONS

	1980	1985	1995	2005	2015	2025	2035
AUTOMOBILES							
Population	1,109,500	1,152,800	1,198,500	1,240,000	1,255,000	1,280,000	1,300,000
Driver/Pop. Ratio	0.58	0.6	0.6	0.6	0.6	0.6	0.6
Licensed Drivers	643,000	691,700	719,100	744,000	753,000	768,000	780,000
Auto/Drivers Ratio	0.87	0.9	0.9	0.9	0.9	0.9	0.9
Automobiles	573,000	622,500	647,200	669,600	677,700	691,200	702,000
Avg. Mi./Year	9,690	9,690	9,690	9,690	9,690	9,690	9,690
Total Mi./Year (1000 Miles)	5,550,000	6,032,025	6,271,368	6,488,424	6,566,913	6,697,728	6,802,380
Avg. Mi./Gal.	16.2	19.0	27.0	27.5	27.5	27.5	27.5
Total Gallons (1000 Gals.)	342,364	317,475	232,273	235,943	238,797	243,554	247,359
Tons/Year 1/	971,728	900,485	658,818	669,227	677,322	690,815	701,609
TRUCKS & BUSES							
Number	143,000	160,500	174,000	189,000	195,000	198,000	200,000
Mi. Driven/Year	10,720	10,720	10,720	10,720	10,720	10,720	10,720
Total Mi./Year (1000 Miles)	1,532,960	1,720,560	1,865,280	2,026,080	2,090,400	21,122,560	2,144,000
Avg. Mi./Gal.	8.8	9.0	9.0	9.0	9.0	9.0	9.0
Total Gallons (1000 Gals.)	174,200	191,173	207,253	225,120	232,267	235,840	238,222
Tons/Year	494,100	542,242	587,852	638,530	658,801	668,936	675,692
Total Tons/Year	1,465,828	1,442,727	1,246,676	1,307,757	1,336,123	1,359,751	1,377,301
Import Demands 2/	1.282	1.282	1.282	1.282	1.282	1.282	1.282
Gasoline Imported/ Year	1,879,191	1,849,600	1,598,200	1,676,500	1,712,900	1,743,200	1,765,700

1/ 352.56 gal./ton
2/ From "Interim Review of Reports, Charleston Harbor, South Carolina," Appendix D, 1974

J. C. Hite, and J. M. Stepp, entitled "Patterns of Energy Usage in South Carolina Manufacturing, 1973-1974," AE395 and published by Clemson University, Clemson, South Carolina, it was indicated that this fuel oil is widely used by manufacturing plants throughout the state. This was confirmed by consultations with officials of local oil distributorships. The residual fuel oil projections were done in four parts. The first part was based on data furnished by the electric companies concerning their present and projected future uses of this fuel oil in their electric generating processes. The 1980 projection is for a total of about 537,900 short tons of residual fuel oil usage for electric power generation, increasing to about 600,400 short tons by the year 2000. The second major portion of usage surveyed is that by the large paper and paperboard mill in the tributary area which was contacted concerning their present use and what they expect to use in the future. It was stated that in the past few years, ending 30 June 1978, they had used about 79,000 short tons per year of residual fuel oil which had come through Charleston Harbor and they had recently signed a contract for about 47,400 short tons to be delivered during the 1 July 1978 - 30 June 1979 period. The 1979-1980 period may see a further decrease in tonnage to about 31,600 short tons. For projection purposes, it was estimated that 31,600 short tons of residual fuel oil commerce per year would be generated for the life of the project by the paper and paperboard industry. During the time frame of the above cited energy usage report by S. D. Sinclair, et al, about 45 percent of total residual fuel oil consumed could be traced to the electric power generating and paper and paperboard industries. Therefore, some 55 percent remained for assignment to other indicators for projection purposes. From data supplied in the Sinclair, et al, report, about two-thirds of this, or 37 percent, was assigned to the Income from Textile Manufacturing and one-third, or 18 percent, to the Income from Chemicals and

Allied Products Manufacturing Indicators. Both of these indicators were derived from the main part of the December 1975, Series E report cited above and sponsored by South Atlantic Division, Corps of Engineers. Modifications were made to retain consistency with Appendix B populations in cited report and to convert incomes to production based on Table 5, Vol. 1, "1972 OBERS Projections", issued by the U. S. Water Resources Council in April 1974. However, no increase in use was projected after 2005, due to uncertainties about petroleum technology and policies. Details are presented in Table B-3.

(c) Distillate fuel oil use was determined on a state-wide basis by the same method as that used for residual fuel oil. That is, by a careful examination of the previously mentioned "Patterns of Energy Usage in South Carolina Manufacturing, 1973-1974" it was determined that this type of fuel oil has broad usage in South Carolina industry. However, the food and kindred products, textile mill products, lumber and wood products, chemicals and allied products, and nonmetallic mining, except fuels, industries each accounted for over five percent of the distillate fuel usage. These indices were applied in the same manner as described for residual fuel oil, including no increase after 2005. Details are presented in Table B-4.

(d) The other petroleum products subcategory, as can be seen in Table B-1, is a combination of waterborne commerce in asphalt, jet fuel, lubrication oils, kerosene and other petroleum products. It may also be noted that there has been a steady decline in Charleston Harbor total commerce in these particular items since about 1972. Due to the diffused markets for these various types of products, the best index of future demand was assumed to be the actual population residing in the petroleum tributary area in the future. No increase was projected after 2005. Details are presented in Table B-5.

TABLE B-3

DETAILED COMPUTATIONS FOR RESIDUAL FUEL OIL
COMPONENT OF PETROLEUM PROJECTIONS

	Textile	Chemical	Electric Utilities	Paper	Total
1976	586,400	285,300	1/	1/	1/
1985	821,000	576,300	566,000	31,600	1,994,900
1995	1,174,000	968,200	599,000	31,600	2,772,800
2005	1,592,700	1,504,100	600,400	31,600	3,728,800
2015	1,592,700	1,504,100	600,400	31,600	3,728,000
2025	1,592,700	1,504,100	600,400	31,600	3,728,000
2035	1,592,700	1,504,100	600,400	31,600	3,728,000

1/ Not Available

TABLE B-4

DETAILED COMPUTATIONS FOR DISTILLATE FUEL OIL
COMPONENT OF PETROLEUM PROJECTIONS

	Food Production	Textile	Lumber & Wood	Chemicals	Clay, Stone & Gravel	Total
1974	38,000	71,200	180,500	90,200	95,000	474,900
1985	50,900	99,600	218,400	182,200	159,600	710,700
1995	64,100	142,400	290,500	306,100	220,200	1,023,300
2005	77,900	193,200	369,100	475,500	284,100	1,399,800
2015	77,900	193,200	369,100	475,500	294,100	1,399,800
2025	77,900	193,200	369,100	475,500	294,100	1,399,800
2035	77,900	193,200	369,100	475,500	294,100	1,399,800

TABLE B-5

DETAILED COMPUTATIONS FOR OTHER PETROLEUM PRODUCTS
COMPONENT OF PETROLEUM PROJECTIONS

Year	Population in Tributary Trade Area
1974	817,400
1985	919,600
1995	965,600
2005	993,200
2015	993,200
2025	993,200
2035	993,200

(e) In all the above subcategories, an adjusted 1974 figure was used as a base for future projected commerce demands. This adjusted 1974 figure was, in general, an average figure for the 1972-1976 time period. It was made to "smooth-out" short term fluctuations and to provide a more realistic beginning figure for projections of a "typical" future year's commerce at a specific point of time. Results are presented in Table B-6.

4. The growth indicator for petroleum product users in this report are shown below:

	Base Tonnage	1985	1995	2005	2015	2025	2035
Petroleum products	77	100	117	143	144	144	145

CHEMICAL PRODUCTS

5. In 1977 chemical products were the fifth leading tonnage group, accounting for 409,176 tons or 4.0 percent of the total commerce. The main items are sodium hydroxide, crude tar, basic chemicals and products, plastic materials, synthetic fibers, and fertilizer and fertilizer materials. The chemical tonnage has increased at a compound rate of about 3.45 percent since 1958.

6. The chemical industry is one of the most important and rapidly growing in the state of South Carolina. The chemical tonnage handled over port facilities has been diverse with no single product accounting for a substantial portion of the chemical tonnage. An attempt was made towards correlating the earnings in the chemical industry for the state of South Carolina with the tonnage of chemicals moving over port facilities. The analysis revealed very little correlation between these two variables. A review of waterborne commerce statistics indicated that a substantial portion of the chemical tonnage could be expected to be used either in the

TABLE B-6

DETAILED PETROLEUM PROJECTIONS

(OCEANGOING COMMERCE)
(Short Tons)

	1974 1/	1985	1995	2005	2015	2025	2035
Gasoline	1,343,721	1,849,300	1,620,000	1,703,000	1,735,000	1,753,000	1,800,000
Residual Fuel Oil	1,584,986	1,994,900	2,772,800	3,728,800	3,728,800	3,728,800	3,728,800
Distillate Fuel Oil	474,908	710,700	1,023,300	1,399,800	1,399,800	1,399,800	1,399,800
Other Petroleum Products	817,384	919,600	965,600	993,200	993,200	993,200	993,200
TOTAL PETROLEUM	4,220,999	5,474,500	6,381,700	7,824,800	7,856,800	7,878,800	7,921,800
VIA: 2/							
COOPER RIVER		4,981,800	5,839,300	7,198,800	7,227,300	7,243,400	7,285,300
SHIPYARD RIVER		492,700	542,400	626,000	629,500	631,400	636,500

1/ Foreign imports and coatwise receipts only. Average of 1972 through 1976.
2/ From data supplied by "Waterborne Commerce" 1960-77 and terminal operators about existing commerce.

textile industry or for agricultural purposes. The recent (1970) completion of a synthetic fiber plant near Charleston Harbor underscores the interrelationship of textile and chemical industries in the state. Thus, a combination of estimates of production of textiles and agriculture were applied. These projections indicate substantial increases in production in future years for the chemical and textile industries and a minor increase in agricultural earnings for the state of South Carolina. With these items as a guide, the chemical tonnage was estimated to increase at an annual rate of 2.4 percent per year from 1974 to 1985, 1.6 percent per year from 1985 to 1995, and 1.5 percent per year from 1995 to 2035. The growth indicators and projected tonnage are shown as follows:

	Indicator	Tonnage
1960		233,223
1970		269,774
1974 (Base Tonnage)	81	374,079
1985	100	463,800
1995	117	542,600
2005	143	663,200
2015	169	783,800
2025	192	890,100
2035	214	992,500

TANKER PROJECTIONS

7. All petroleum products and many chemicals are currently transported in deep draft tankers. Due to channel limitations at those terminals serving much of the bulk chemical commerce locally, the size of tankers transporting these products will remain the same as the vessels in the existing fleet. Projections were made, however, for the number and size of tankers transporting petroleum products which can be expected to use Charleston Harbor during the years 1985, 1995, 2005, 2015, 2025 and 2035

for the various channel depths considered in this report. The projections were made based on the analysis of past trends of the makeup of the existing world, United States and Charleston Harbor fleets, of vessels under construction, and future trends predicted by various technical publications.

WORLD TANKER FLEET

8. The continuing trend of developing and operating vessels of ever increasing size, as discussed above, is further documented in Table B-7. This table summarizes by year the number of vessels, deadweight tonnages (DWT), and percent of the fleet deadweight tonnage for selected draft groups comprising the world tanker fleet for the period 1958 through 1976. This tabulation shows that the number of vessels and deadweight tonnage of the fleet have steadily increased in recent years. More important, in 1958 over half of the world tanker fleet deadweight tonnage consisted of vessels with drafts under 31 feet. It can be seen that during the tabulated period the percent of the fleet deadweight tonnage contributed by these vessels steadily decreased from 53.7 percent to 3.2 percent. The same trend is observed for the 31- to 36-foot draft groups. The antithesis is evident for the vessel groups with drafts of 36 feet or greater. In 1958, vessels with drafts of 36 feet or greater comprised less than 10 percent of the world tanker fleet total deadweight tonnage. Based on the latest available data, the 36 to 40 feet and 40 feet and over groups now represent 9.0 percent and 82.6 percent of the total deadweight tonnage, respectively. It is therefore evident that there has been a continual replacement of the older and smaller vessels, with vessels of increased capacity and drafts of 36 feet and greater.

9. The latest composition of the world tanker fleet available at the time of this study is presented in Table B-8. Here it is shown that the world tanker fleet consists of 5,140 vessels aggregating almost four hundred million deadweight tons. In addition, as of 31 December 1976,

TABLE B-7

TRENDS IN WORLD TANKER FLEET

Year	Vessels	Total DWT (1000)	PERCENT OF TOTAL VESSEL FLEET						
			Under 31 ft	31 to 33	33 to 36	36 to 40		40 and over	
						33 to 37	37 to 40		Over 40
1958		56,641	53.7	16.2	20.3		8.5		1.3
1959	3,276	62,658	48.0	15.6	21.7		12.4		2.3
1960	3,264	65,780	42.8	15.6	22.7		16.0		2.9
1961	3,250	68,859	38.0	15.8	22.7		19.5		4.0
1962	3,259	71,996	33.9	15.6	22.8		22.0		5.7
1963	3,279	76,180	30.5	14.6	22.0		24.6		8.3
1964	3,359	85,126	25.8	13.2	20.0		25.7		15.3
1965	3,436	93,172	22.6	12.1	15.2		25.8		24.3
1966	3,524	102,909	19.7	10.8	16.3		24.7		28.5
1967	3,613	112,366	17.6	9.5	13.8		23.4		35.7
1968	3,748	126,454	15.3	8.9	11.4		20.5		43.9
1969	3,893	146,029	11.2	8.6	9.4		17.7		53.1
1970	3,994	166,776	9.2	7.7	8.1		15.6		59.4
1971	4,183	191,748	8.1	6.6	7.1		13.9		64.3
1972	4,336	220,882	6.6	5.9	6.1		12.3		69.1
1973	4,572	256,204	NA	NA	NA		NA		NA
1974	4,892	302,277	6.1	6.0		5.9		8.6	73.4
1975	5,092	347,144	4.9	5.1		5.5		7.4	77.0
1976	5,140	382,534	3.2	3.1	2.1		9.0		82.6

Source: "Analysis of World Tank, Ship Fleet, December 31, 1958 - December 31, 1976" Sun Shipbuilding and Drydock Company.

TABLE B-8

COMPOSITION OF UNITED STATES AND WORLD TANKER FLEETS
December 1976

Draft Range (Ft.)	U.S. Tanker Fleet (Less U.S. Military)			World Tanker Fleet (Less U.S. Military)			Approximate Average DWT
	No.	Tons Per Group	Percent of Total	No.	Tons Per Group	Percent of Total	
10 to 20	2	7,913	0.1	248	1,004,076	0.3	4,000
20 to 25	0	0	0	503	2,934,281	0.8	5,800
25 to 30	2	30,233	0.3	316	3,906,889	1.0	12,400
30 to 31	22	391,871	3.7	250	4,453,991	1.2	17,800
31 to 32	7	136,829	1.3	349	7,073,426	1.8	20,300
32 to 33	16	421,612	4.0	217	4,850,333	1.3	22,400
33 to 34	29	765,816	7.3	150	3,818,475	1.0	25,500
34 to 35	37	1,060,785	10.1	142	4,060,104	1.1	28,600
35 to 36	17	565,358	5.4	135	4,322,307	1.1	32,000
36 to 37	22	759,759	7.2	247	8,390,276	2.2	34,000
37 to 38	19	701,820	6.7	160	5,976,989	1.6	37,400
38 to 39	9	398,292	3.8	193	8,637,465	2.2	44,800
39 to 40	7	318,436	3.0	140	6,964,018	1.8	49,700
40 to 41	10	515,861	4.9	138	7,621,359	2.0	55,200
41 to 42	3	227,898	2.2	105	6,407,112	1.7	61,000
42 to 43	1	67,847	0.6	118	8,086,902	2.1	68,500
43 to 44	5	337,500	3.2	75	5,134,222	1.3	68,500
44 to 45	9	674,465	6.4	116	9,440,663	2.5	81,400
45 to 46	1	67,400	0.6	54	4,213,638	1.1	78,000
46 to 47	3	231,606	2.2	88	7,679,934	2.0	87,300
47 to 48	0	0	0	51	4,566,093	1.2	89,500
48 to 49	0	0	0	57	5,421,468	1.4	95,100
49 to 50	8	733,767	7.0	76	7,358,119	1.9	96,800
50 to 51	0	0	0	58	6,329,095	1.6	109,100
51 to 52	0	0	0	30	3,253,449	0.8	108,400
52 to 53	4	482,231	4.6	42	4,965,787	1.3	118,200
53 to 54	1	114,669	1.1	25	3,017,090	0.8	120,700
54 to 55	0	0	0	52	7,137,020	1.9	137,200
55 & over	7	1,497,450	14.3	1,005	225,509,894	59.0	224,400
	241	10,508,418	100.0	5,140	382,533,975	100.0	74,400

Source: "Analysis of World Tank Ship Fleet, December 31, 1976," April, 1978, Sun Shipbuilding & Dry Dock Co.

there were 520 vessels of aggregating over fifty million tons on order or under construction. There were 2,830 in service with loaded drafts of 36 feet or greater. An additional 387 vessels of 32,000 DWT or larger with loaded drafts of 35 feet or more will be in the world tanker fleet in the near future.

UNITED STATES TANKER FLEET

10. Even though there has been a continual replacement of the older vessels, the U. S. tanker fleet remains the oldest fleet in the world with an average age of 13 years and 3 months. The expected useful life of a tanker is considered to be about 20 years, therefore, those vessels constructed prior to 1956 have been or are being replaced and are not expected to be in service during the initial years of the project.

11. In 1959, the U. S. tanker fleet contained 336 vessels, of which 76 percent (256) were constructed prior to 1952. Of the 256 vessels constructed prior to 1952, 89 percent were constructed during the period 1941 through 1945. The percentage of the vessel fleet constructed prior to 1952 has diminished yearly and in 1962, 1969, and 1972 was 68 percent, 54 percent, and 39 percent, respectively. In 1976, the percentage of the vessel fleet constructed prior to 1957 was 27 percent.

12. Table B-9 summarizes by year the number of vessels, DWT, and percent of the fleet DWT for selected draft groups for the period 1958 through 1976. This tabulation shows that even though there was a continual decline in the number of vessels in the U. S. tanker fleet prior to 1976, the fleet capacity has increased yearly. Further analysis of this tabulation reveals that in 1958 over half of the fleet DWT consisted of vessels with drafts of less than 31 feet. It can be seen that for the tabulated period this percentage steadily decreased from 66.4 percent to 4.1 percent. The percentage of the fleet DWT

TABLE B-9

TRENDS IN U. S. TANKER FLEET

Year	Vessels	Total DWT (1,000)	Percent of Total Fleet					
			Under 31 ft	31 to 33	31 to 34	33 to 36	34 to 36	36 to 40	40 and over
1958		6,182	66.4	11.2		20.0		2.4	0
1959	337	6,633	60.8	10.5		23.4		4.3	1.0
1960	328	6,729	56.3	10.6		24.3		7.8	1.0
1961	318	6,905	47.7	14.8		24.9		10.3	2.3
1962	305	6,870	42.6	15.7		26.9		11.0	3.8
1963	291	6,772	38.9	16.7		28.1		13.4	3.9
1964	279	6,745	34.0	17.9		30.1		14.3	4.9
1965	268	6,650	30.6	17.9		31.0		14.4	6.1
1966	270	6,753	29.5	18.1		32.3		14.2	5.9
1967	271	6,845	28.2	16.7		34.7		14.5	5.9
1968	271	6,979	25.4	17.4		33.0		18.4	5.8
1969	260	7,300	19.3	14.2		35.3		21.8	9.4
1970	255	7,372	17.0	14.2		33.8		20.2	14.8
1971	251	7,652	13.7	13.0		32.1		22.1	19.1
1972	238	7,757	10.1	10.6		32.0		24.2	23.1
1973	NA	NA	NA	NA		NA		NA	NA
1974	230	9,031 (rounded)	6.6		24.8		22.9	12.1	33.6
1975	238	9,497 (rounded)	6.1	7.0		27.3		19.9	39.7
1976	241	10,548 (rounded)	4.1	5.3		22.8		20.7	47.1

Source: "Analysis of World Tank Ship Fleet, December 31, 1958-December 31, 1976", Sunbuilding and Drydock Company.

consisting of vessels with drafts of 31 to 33 feet decreased from a high of 18.1 percent in 1966 to 5.3 percent in 1976, while vessels with drafts of 33 to 36 feet showed first an increase, then a decrease during this period. However, it can be seen from the tabulation that the most pronounced change occurred in vessels with drafts of 36 feet or greater. In 1958, vessels with drafts of 36 feet to 40 feet comprised only 2.4 percent of the fleet DWT versus 20.7 percent in 1976, down from 24.1 percent in 1972. A more pronounced growth, 0 percent in 1958 and 47.1 percent in 1976, is observed for vessels with drafts of 40 feet or more. Table B-10 shows the composition of the U. S. and world tanker fleets under construction or on order as of December 31, 1976.

TANKER FLEET USING CHARLESTON HARBOR

13. At the time this study was made, the latest statistics on trips and loaded drafts over the waterway were contained in the Corps of Engineers' publication "Waterborne Commerce of the United States" for calendar year 1977. Table B-11 contains the trips and loaded drafts of vessels over the waterway during the recent past. This tabulation illustrates by year the total number of inbound and outbound vessel trips, vessel trips with loaded drafts less than 31 feet, and vessel trips equaling or exceeding the corresponding loaded draft for those vessel trips with loaded drafts of 31 feet or greater.

14. Analysis of the inbound traffic presented in Table B-11 shows there was an increase in vessel trips over the waterway for the period from 1963 through 1973. It can be seen that the vessel trips with loaded drafts equaling or exceeding 31 feet increased from 150 in 1963 to a high of 197 in 1971, and then decreased to 153 in 1976. The 197 vessel trips constituted over half (64.6%) of the total 1971 vessel trips over

TABLE B-10

COMPOSITION OF UNITED STATES AND WORLD TANKER FLEETS UNDER CONSTRUCTION
OR ON ORDER AS OF DECEMBER 31, 1976

Deadweight Tonnage In Thousands	U.S. Tanker Fleet Under Construction Or On Order As Of December 31, 1976			World Tanker Fleet Under Construction Or On Order As Of December 31, 1976			Approximate Average DWT	Approximate Average Draft
	No.	Tons Per Group	Percent of Total	No.	Tons Per Group	Percent of Total		
Under 10	0	0		65	397,800	0.8	6,100	19
10 to 20	0	0	0	34	488,400	0.9	14,400	27
20 to 30	0	0	0	34	873,400	1.7	25,700	33
30 to 40	5	178,300	3.0	65	2,096,200	4.0	32,200	35
40 to 50	0	0	0	26	1,126,300	2.1	43,300	38
50 to 60	3	168,000	2.8	37	2,029,800	3.9	54,900	40
60 to 70	18	1,147,800	19.2	43	2,747,500	5.2	63,900	41
70 to 80	0	0	0	2	146,700	0.3	73,400	43
80 to 90	5	448,500	7.5	15	1,291,300	2.5	86,100	45
90 to 100	0	0	0	30	2,912,000	5.5	97,100	46
100 to 110	0	0	0	3	306,000	0.6	102,000	47
110 to 120	2	236,300	4.0	6	692,500	1.3	115,400	50
120 to 130	0	0	0	15	1,837,000	3.5	122,500	51
130 to 140	0	0	0	18	2,407,200	4.6	133,700	53
140 to 150	0	0	0	4	576,000	1.1	144,000	54
150 & Over	17	3,792,400	63.5	123	32,544,700	62.0	264,600	67
TOTAL	50	5,971,600	100.0	520	52,472,800	100.0	100,900	47

Source: "Analysis of World Tank Ship Fleet, December 31, 1976," April, 1978, Sun Shipbuilding & Dry Dock Co.

TABLE B-11

CHARLESTON HARBOR TRIPS AND LOADED DRAFTS (TANKERS)

Draft (Ft.)	Trips by Year														
	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
Inbound Traffic															
Less than 31	106	108	138	120	114	131	103	129	108	130	142	121	91	101	109
Equal to or Greater than 31	150	153	143	162	170	174	197	194	197	172	175	177	150	153	184
32	106	123	112	124	128	132	157	157	176	145	157	157	129	127	142
33	74	73	64	62	68	83	104	117	122	114	134	127	97	100	117
34	46	41	33	37	43	57	62	73	69	75	92	89	62	72	98
35	22	16	16	21	23	34	39	33	27	30	59	62	36	39	75
36	2	3	2	4	1	8	6	4	8	6	10	15	4	2	0
37						1			3	3	0	0	0	0	0
Total Vessel Trips	256	261	281	282	284	305	300	323	305	302	317	298	241	254	293
Outbound Traffic															
Less than 31	263	266	273	268	246	281	267	292	272	290	313	276	230	231	274
Equal to or Greater than 31	14	15	10	14	30	15	29	25	23	16	14	18	10	14	12
32	11	11	6	8	17	9	18	17	14	11	13	16	7	13	7
33	8	9	2	4	6	4	11	10	7	8	5	13	5	7	5
34	4	4	1	1	2	1	7	6	2	7	3	8	1	4	2
35				1	1		3	4	1	4	3	5	1	3	0
36				1				1			2	3	0	0	0
Total Vessel Trips	277	281	283	282	276	296	296	317	295	306	327	294	240	245	286

SOURCE: Compiled from 1963-1977 Editions, "Waterborne Commerce of the United States"

the waterway. The vessel trips comprised of vessels with loaded drafts of 31 to 32 feet decreased by 60 percent over the period 1963 through 1973, then increased somewhat thereafter. During this same period, there were corresponding increases in the remaining draft groups (greater than 32 feet) that tended to offset the loss in the 31- to 32-foot group. The data for 1972 is not considered typical of the trend established during the period 1963 through 1971. The 1972 data is considered to reflect the increasing reluctance of harbor pilots to pilot the larger vessels and culminated in 1973 by a public announcement that the services of pilots will not be available for vessels with drafts displacing more than 35 feet regardless of whether or not a full release is offered pilots by such vessels. During 1972, there was an increase in the vessel trips with loaded drafts less than 31 feet and a corresponding decrease in the vessel trips with loaded drafts equal to or greater than 31 feet. However, the vessel trips from 1972 on with drafts equaling or exceeding 31 feet still constituted over half of the total inbound vessel trips over the waterway.

15. The above establishes that, during the recent past, over half of the inbound tanker trips occurred with vessels having loaded drafts of 31 feet or greater. Obviously, the waterway is being utilized to its fullest extent and vessel operators are already crowding, if not exceeding, the existing channel draft limits. However, the above analysis does not define the operating or dimensional characteristics of vessels utilizing the waterway. Analyses were made of the "Charleston Harbor Pilots Association Log" for selected years to obtain actual vessels and their trips and drafts over the waterway. The dimensional characteristics (draft, DWT, etc.) of each vessel was then obtained from the "Lloyd's Register of Shipping" vessel publication for the 1973 study and the State Ports Authority for this study. Comparisons of the vessels' maximum draft and the actual loaded drafts were made to determine if they were being utilized fully loaded, light loaded, tidal advantage, etc.

16. Table B-12 summarizes, for selected years, the number of vessel trips, total fleet deadweight tonnage, and percent of the fleet deadweight tonnage compiled from the "Charleston Harbor Pilots Association Log", "Lloyd's Register of Shipping," and the State Ports Authority. This tabulation shows that there has been a continual increase in the vessel trips and DWT of the Charleston Harbor fleet. It can be seen that in 1958 almost half (44%) of the Charleston Harbor fleet DWT consisted of vessels with design (maximum) drafts under 31 feet. During the tabulated period, the percent of the fleet DWT contributed by these vessels declined to a low of 9 percent in 1972 and then increased to 11 percent in 1977. The percentage contributed by vessels of 31 to 33 feet drafts doubled between 1958 and 1972, then decreased to about 10 percent in 1958 to a high of over 45 percent in 1968, then decreasing to about one-half that percentage in 1977. The 36 to 40 feet draft category increased its share some five and one-half times between 1958 and 1977, while the 40 feet and over category has remained small. These fluctuations illustrate the continuing flexibility or the trade patterns served by the world tanker fleet.

17. Table B-13 contains the number of vessel trips by year and corresponding design vessel draft compiled from the "Charleston Harbor Pilots Association Log," "Lloyd's Register of Shipping," and the South Carolina State Ports Authority for those vessels having a draft of 31 feet or greater. Analysis of this tabulation reveals that approximately 74 and 67 percent of the vessel trips occurred with vessels having drafts of 31 to 34 feet for 1971 and 1972, and 42 percent in 1977. Table B-14 contains the number of vessel trips by draft and corresponding period of construction for those vessels comprising the trips. It can be seen from this tabulation that 105 (36%) of the 288 vessel trips in 1977 occurred with vessels having drafts of 31 to 34 feet. Of the 105 vessel trips, 76 occurred with vessels constructed prior to 1962, 42 with vessels constructed prior to 1957, and 7 with vessels constructed prior to 1952. Therefore, by the initial project year (1985), it is expected that the majority of the vessels in this draft

TABLE B-12

TRENDS IN TANKER FLEET USING CHARLESTON HARBOR

Year	Vessel Trips	Total Deadweight Tonnage (1000)	Percent of DWT by Design (Max.) Draft				
			Under 31 Feet	31 to 33 Feet	34 to 36 Feet	36 to 40 Feet	40 Feet & Over
1958	179	3,392	43.1	19.6	30.6	6.7	
1960	213	4,575	32.7	29.5	31.8	1.9	4.1
1968	249	5,568	23.1	25.1	45.3	5.6	.9
1972	259	6,304	9.3	39.1	43.7	7.9	
1977	289	8,506	11.0	21.6	22.6	43.6	1.2

SOURCE: Compiled from analysis of "Charleston Harbor Pilot's Association Log," "Lloyd'd Register of Shipping," U.S. Department of Commerce's "Merchant Fleets of the World" - as of June 30, 1972 and 1978, and S.C.P.A. information.

TABLE B-13

CHARLESTON HARBOR TRIPS BY DESIGN (MAXIMUM) DRAFTS

Vessel Draft (Ft.)	Trips by Year					
	1968	1969	1970	1971	1972	1977
31	30	53	52	46	59	24
32	28	37	37	25	35	51
33	64	68	81	86	55	30
34	12	31	25	20	45	24
35	12	16	20	22	13	16
36	4	5	8	5	5	18
37	1	4	3	4	1	45
38	3	2	3	-	10	43
39	1	3	-	-		1
40	-	-	-	1		-
41	1	-	1	-		-
42		-	2	-		-
43		2	1	2		1
44		-		-		-
45		-		-		-
46		1		1		-
TOTAL	156	222	233	212	223	253

SOURCE: Compiled from analysis of "Charleston Harbor Pilot's Association Log" and Lloyd's Register of Shipping", and data furnished by the South Carolina State Ports Authority.

range will have been replaced by the newer and larger vessels or nearing the end of their serviceable life and scheduled for replacement.

18. The increasing availability of larger vessels (Tables B-7 through B-10), the utilization of deeper draft vessels over the waterway (Tables B-11 through B-13), the age distribution of the Charleston fleet (Table B-14), information which had been obtained from users of the waterway, information on vessels being built, and judgment were used to forecast the future fleet. Contacts with shippers of petroleum products over the waterway had revealed: (a) most had enough storage capacity at present to accommodate larger shipments; (b) all contained sufficient room for expansion; (c) practically no use was made of small vessels from the world fleet; and (d) the majority of shipments are currently made in 28,000 DWT range vessels. Waterway needs at Charleston will then be influenced primarily by the capabilities of the receiving and storage terminals to handle the larger volumes transported in the larger vessels as shippers are expected to continue using the largest practicable vessels available. Therefore, it is expected that the majority of the petroleum receipts at Charleston will be transported in vessels with a draft range of 34 to 40 feet and a deadweight tonnage range of about 26,000 to 56,000 tons. By the years 1985, 1995, 2005, 2015, 2025 and 2035, the expected distribution of tanker sizes at Charleston for a 40-foot project is shown in Table B-15.

PETROLEUM BENEFITS

19. The use or claiming of full benefits in determining the economic justification of considered improvements to the Charleston waterway requires commensurate depths in the ports at the other end. All but a small percentage of these domestic shipments originate from the existing 40-foot Texas Gulf ports or Port Arthur and Houston. Therefore, the total benefits computed for the movement of domestic petroleum and

TABLE B-14

AGE DISTRIBUTION OF TANKERS USING CHARLESTON HARBOR IN 1977

Period Constructed	Number of Tankers									
	30 ft Under	31 ft	32 ft	33 ft	34 ft	35 ft	36 ft	37 ft	38 ft	39 ft Over
1972-1977	-	2	6	7	6	7	3	35	8	-
1967-1971	1	3	1	3	2	-	5	5	-	-
1962-1966	-	-	5	2	3	-	7	1	-	-
1957-1961	31	10	7	17	7	9	3	4	35	2
1952-1956	1	9	26	-	7	-	-	-	-	-
1947-1951	-	-	-	1	-	-	-	-	-	-
1942-1946	1	-	6	-	-	-	-	-	-	-
TOTAL	34	24	51	30	25	16	18	45	43	2

SOURCE: From data supplied by the South Carolina State Ports Authority.

TABLE B-15

TANKER PROJECTIONS FOR 40-FOOT PROJECT

Draft Range (Ft.)	DWT Range (Tons)	Percent of Traffic by Year						
		1977	1985	1995	2005	2015	2025	2035
Under 34	16,000 to 26,000	36.9	30	18	10	6	3	0
34 to 38	26,000 to 47,000	39.5	40	45	45	45	45	45
38 to 40	47,000 to 56,000	22.9	25	30	35	37	39	40
Over 40	56,000 to 90,000	0.7	5	7	10	12	13	15

petroleum products over improved waterway depths up to and including 40 feet were credited to improvement of the Charleston waterway. Only one-half of the incremental benefits for improved depths greater than 40 feet were claimed for the Charleston waterway, as half are credited or reserved for port improvement at the other end of the line. In foreign trade it is known that deep draft commerce tends to be concentrated in ports of adequate natural depths. For those ports requiring improvement, the portion of improvement required to accommodate the Charleston Harbor waterway traffic cannot be readily determined or identified. Accordingly, for the items of commerce in foreign trade considered in this study, to be benefited by project modifications, full benefits are claimed for improvements to the Charleston Harbor waterway.

20. The cost per ton (unit cost) was computed for the movement of petroleum and petroleum products in domestic and foreign trade for tankers of 22,500 to 86,000 DWT capacities and draft increment of one foot for the following conditions: fully loaded; 1-foot light; 2-feet light; 3-feet light; and 4-feet light at the various tidal conditions (MLT, normal tide, high tide). It is assumed that the tankers would come in loaded and return empty. The commerce moved in coastwise trade were based on the average sailing distance between Charleston, South Carolina, and the aforementioned Texas Gulf ports as all but a small percentage of the domestic petroleum commerce originates from these Texas ports. Foreign unit cost computations for commerce moved in foreign trade, were based on the average sailing distance to the Venezuelan ports of Aruba and Amuay as they are expected to continue to contribute all but a small fraction of the foreign trade. The following was used in calculating the unit cost:

$$\text{Unit Cost} = \text{Total Round Trip Cost} \div \text{Cargo Capacity}$$

where

$$\text{Total Round Trip Cost} = \left(\text{Time at sea}\left(\frac{\text{Distance}}{\text{Speed}}\right) \times \text{Operating Cost at Sea}\right) + \left(\text{Time in port}\left(\frac{2\text{x Cargo}}{\text{Loading Rate}}\right) \times \text{Operating Cost in Port}\right)$$

$$\text{Cargo Capacity (Fully Loaded)} = \text{DWT of Vessel} \times 1.12 \times .96$$

$$\text{Cargo Capacity (Light Loaded)} = (\text{DWT} \times 1.12 \times .96) - (\text{Ft. Light Loaded} \times (\text{IMF} \times 12))$$

21. The tide tables for Charleston Harbor were graphically plotted and the information was determined on: (a) tidal advantage for normal and spring (high) tide, (b) maximum delay which could be expected for each of these conditions and (c) tidal cycle. Table B-16 shows this information.

22. A sample calculation utilizing a 33,500 DWT tanker on a domestic run between Texas and South Carolina is shown on Table B-17. This computation demonstrates the wide range of unit cost ($6.55 to $7.77) obtainable depending on how the vessel is utilized, that is, fully loaded, light loaded and/or tidal advantage. The selected vessel fleets to be benefited by additional channel depth at Charleston, the percentage of commerce to be transported by vessel size, and unit costs were utilized to obtain the weighted unit transportation cost for domestic and foreign shipments over the existing 35-foot waterway and improved channel depths. The average unit cost (total weighted cost) is calculated by multiplying the unit cost of the various size vessels making up the fleet which will be using the waterway for each selected year times the percent commerce each of the various size vessels will be handling. The percent of commerce was derived by the utilization of the previously projected vessel fleet breakdown by draft increments of one foot. Knowing the cargo carried by each of the vessels and the total commerce expected, the percent of commerce for each 1-foot draft increment was derived. The average unit cost for the 35-foot project is shown on Table B-18. The vessel fleet for the 35-foot project is assumed to remain constant through the life of the project. The average unit cost for the selected years of the 40-foot

TABLE B-16
TIDAL INFORMATION

Tide	Max. Ft. Available	Maximum Delay (Hrs)	Tidal Cycle (Hrs)
Normal	2	9	12.5
Spring (High)	4	10	12.5

The average delay and delay cost for vessels using the tide is based on the following formulas:

$$\text{Average Delay} = (\text{Max. Delay})^2 \div (2 \times \text{Tidal Cycle})$$

$$\text{Delay Cost} = \text{Average Delay} \times \text{Cost at Sea}$$

The unit cost for vessels using tidal advantage is:

$$\text{Unit Cost} = \frac{(\text{Total Cost at Sea}) + (\text{Delay Cost}) + (\text{Total Cost in Port})}{\text{Cargo Capacity}}$$

TABLE B-17
TANKER UNIT COST - SAMPLE CALCULATIONS

	Fully Loaded	Light Loaded 1 Foot	2 Feet	3 Feet	4 Feet	Tidal Advantages Normal	Spring
VESSEL SIZE (DWT)	33,500						
Available Information							
Draft	36 Ft. 1/						
IMF (Short Tons)	125 1/						
Loading Rate (Tons/Hr.)	1,592 1/						
In Port Cost ($/Hr.)	972 1/						
Distance (Nautical Miles)	2,700 1/						
Speed (Knots)	16 1/						
Cost at Sea	1,138						
Tidal Advantage (Ft.) 2/						2	4
Maximum Delay (Hrs.) 2/						9	10
Tidal Cycle (Hrs.) 2/						12.5	12.5
Total Vessel Cost in Port (Cargo ÷ Capacity + Loading Rate x Cost/Hr.)							
Cargo Capacity (DWT x 1.12 x .96) - (Ft. Light Loaded x IMF x 12)	36,019	34,519	33,019	31,519	30,019		
Time in Port (Cargo ÷ Rate) x 2	45.3	43.4	41.5	39.6	37.7		
Total in Port Cost (Time x Hourly in Port Cost)	$44,032	$42,185	$40,338	$38,491	$36,644		
Total Vessel Cost at Sea (Distance / Speed or Time x Hourly Cost at Sea)							
Time at Sea	168.75						
Total at Sea Cost	$192,038						
Tidal Delay Cost (Avg. Delay x Hourly cost at Sea)							
Average Delay: Max. Delays / 2 x Tidal Cycle						3.2	4
Delay Cost						3,642	4,552
Total Cost (Cost in Port and Cost at Sea and Delay Cost)							
No Tidal Advantage	236,070	234,723	232,376	230,529	228,682		
Normal Tidal Advantage	239,712	237,865	236,018	234,171	232,324		
Spring Tide Advantage	240,622	238,775	236,928	235,081	233,234		
Unit Cost (Total Cost ÷ Cargo Capacity)							
No Tidal Advantage	6.55	6.78	7.04	7.31	7.62		
Normal Tidal Advantage	6.65	6.89	7.15	7.43	7.74		
Spring Tide Advantage	6.68	6.92	7.17	7.46	7.77		

1/ Based on Data Furnished by OCE

2/ Tide Charts

TABLE B-18

AVERAGE COST - PETROLEUM PRODUCTS
CHARLESTON HARBOR 35-FOOT PROJECT

COASTWISE VESSELS

TIDE CONDITION	DRAFT IN/FT	CARGO	LOADING CONDITION	UNIT COST $/Ton	1985 PERCENT COMMERCE	1985 WEIGHTED COST	1995 PERCENT COMMERCE	1995 WEIGHTED COST	2005 PERCENT COMMERCE	2005 WEIGHTED COST	2015 PERCENT COMMERCE	2015 WEIGHTED COST	2025 PERCENT COMMERCE	2025 WEIGHTED COST	2035 PERCENT COMMERCE	2035 WEIGHTED COST
No	32.0	24485.0	1-Ft. Light	9.42	8.28	0.78										
Normal	32.0	25697.0	Fully Loaded	9.19	3.48	0.32										
No	33.0	24790.0	2-Ft. Light	9.29	7.53	0.70										
Normal	33.0	27310.0	Fully Loaded	8.72	5.50	0.48										
No	34.0	25428.0	3-Ft. Light	8.90	6.85	0.61										
Normal	34.0	28116.0	1-Ft. Light	8.32	6.73	0.56										
Maximum	34.0	29460.0	Fully Loaded	8.03	0.	0.										
No	35.0	26592.0	4-Ft. Light	8.51	7.16	0.61										
Normal	35.0	29424.0	2-Ft. Light	7.94	6.04	0.48										
Maximum	35.0	32256.0	Fully Loaded	7.39	3.24	0.24										
Normal	36.0	31519.0	3-Ft. Light	7.43	12.78	0.95										
Maximum	36.0	34519.0	1-Ft. Light	6.92	5.92	0.41										
Normal	37.0	34259.0	4-Ft. Light	6.92	17.48	1.21										
Maximum	37.0	37451.0	2-Ft. Light	6.46	8.82	0.57										
			TOTAL WEIGHTED COST	=		7.93		7.93		7.93		7.93		7.93		7.93

NOTE: Vessel fleet for the 35-foot project is assumed to remain the same for the life of the project.

FOREIGN VESSELS

TIDE CONDITION	DRAFT IN/FT	CARGO	LOADING CONDITION	UNIT COST $/Ton	1985 PERCENT COMMERCE	1985 WEIGHTED COST	1995 PERCENT COMMERCE	1995 WEIGHTED COST	2005 PERCENT COMMERCE	2005 WEIGHTED COST	2015 PERCENT COMMERCE	2015 WEIGHTED COST	2025 PERCENT COMMERCE	2025 WEIGHTED COST	2035 PERCENT COMMERCE	2035 WEIGHTED COST
No	32.0	23303.0	1-Ft. Light	6.45	7.90	0.51										
Normal	32.0	24515.0	Fully Loaded	6.25	3.36	0.21										
No	33.0	24814.0	2-Ft. Light	6.37	7.53	0.48										
Normal	33.0	27310.0	Fully Loaded	5.93	5.56	0.33										
No	34.0	26182.0	3-Ft. Light	5.96	7.04	0.42										
Normal	34.0	28798.0	1-Ft. Light	5.55	6.84	0.38										
Maximum	34.0	30106.0	Fully Loaded	5.35	0.	0.										
No	35.0	27800.0	4-Ft. Light	5.63	7.46	0.42										
Normal	35.0	30512.0	2-Ft. Light	5.25	6.28	0.33										
Maximum	35.0	33224.0	Fully Loaded	4.89	3.47	0.17										
Normal	36.0	32094.0	3-Ft. Light	4.96	13.10	0.65										
Maximum	36.0	34926.0	1-Ft. Light	4.62	5.84	0.27										
Normal	37.0	35121.0	4-Ft. Light	4.66	17.81	0.83										
Maximum	37.0	38097.0	2-Ft. Light	4.35	8.96	0.39										
			TOTAL WEIGHTED COST	=		5.40		5.40		5.40		5.40		5.40		5.40

Above note applies to the foreign fleet.

project is shown on Table B-19. The transportation savings (benefits) is the difference between the weighted transportation costs for the 35-foot waterway and improved channel depth being considered. The transportation savings for a 40-foot project depth are derived in Table B-20. This table is typical of the method used to compute the transportation savings for each of the improved project depths considered.

23. The method used for calculating benefits for the coastwise petroleum products for a 42-foot project is shown in Table B-21. The estimated annual savings at the various depths investigated for Charleston Harbor are shown on Table B-22.

Containership Benefits

GENERAL

24. The volume of cargo to be moved by containerships cannot be as easily identified as can that by tankers and dry bulk carriers. Movement of containerized cargo in Charleston Harbor did not represent a significant volume until 1968. Since 1968, the rate of transition from general cargo vessels to containerships has been phenomenal. The following paragraphs discuss containerization in Charleston Harbor and derive a method for estimating the future tonnage of containerized cargo.

HISTORICAL TREND

25. The containerized cargo handled in Charleston Harbor has increased from 93,021 tons in 1968 to 605,925 tons in 1972, a compound rate of growth of about 60 percent. The tonnage in 1976 was in excess of 1.2 million tons, almost 1.3 million tons in 1977, and was in excess of 1.7 million tons in 1978. It is not expected that this growth will continue

TABLE B-19

AVERAGE COST PETROLEUM PRODUCTS
CHARLESTON HARBOR 40-FOOT PROJECT

TIDE CONDITION	DRAFT IN/FT	CARGO	LOADING CONDITION	UNIT COST $/Ton	1985 PERCENT COMMERCE	1985 WEIGHTED COST	1995 PERCENT COMMERCE	1995 WEIGHTED COST	2005 PERCENT COMMERCE	2005 WEIGHTED COST	2015 PERCENT COMMERCE	2015 WEIGHTED COST	2025 PERCENT COMMERCE	2025 WEIGHTED COST	2035 PERCENT COMMERCE	2035 WEIGHTED COST
Coastwise Vessels																
No	32.0	25697.0	Fully Loaded	9.06	5.52	0.50	3.87	.35	1.88	.17	-	-	-	-	-	-
No	33.0	27310.0	Fully Loaded	8.59	7.34	0.63	5.48	.47	3.95	.34	-	-	-	-	-	-
No	34.0	29460.0	Fully Loaded	7.88	9.52	0.75	6.73	.53	5.71	.45	4.82	.38	3.44	.27	1.26	.10
No	35.0	32256.0	Fully Loaded	7.25	10.34	0.75	7.31	.53	.17	.52	6.75	.49	5.94	.43	5.09	.37
No	36.0	36019.0	Fully Loaded	6.55	12.52	0.82	10.09	.71	10.52	.69	10.07	.66	9.93	.65	9.00	.59
No	37.0	39047.0	1-Ft. Light	6.12	8.33	0.51	8.83	.54	9.48	.58	9.13	.56	9.00	.55	9.63	.59
Normal	37.0	40643.0	Fully Loaded	6.02	7.65	0.46	7.15	.43	6.99	.42	7.64	.46	7.49	.45	8.29	.50
No	38.0	43089.0	2-Ft. Light	5.71	9.29	0.53	9.82	.56	10.50	.60	13.03	.63	10.87	.62	11.72	.67
Normal	38.0	46449.0	Fully Loaded	5.46	7.51	0.41	8.25	.45	9.16	.50	9.60	.53	10.63	.58	10.43	.57
No	39.0	45457.0	3-Ft. Light	5.53	3.62	0.20	4.53	.25	4.52	.25	6.32	.35	6.34	.35	6.14	.34
Normal	39.0	48985.0	1-Ft. Light	5.29	6.62	0.35	0.44	.52	10.77	.57	11.32	.60	12.30	.65	13.23	.70
Maximum	39.0	50749.0	Fully Loaded	5.16	4.07	0.21	3.89	.20	5.04	.26	5.81	.30	5.82	.30	5.80	.30
No	40.0	50296.0	4-Ft. Light	5.36	1.31	0.07	0.31	.07	1.30	.07	2.41	.13	2.25	.12	2.23	.12
Normal	40.0	54232.0	2-Ft. Light	5.12	1.37	0.07	2.74	.14	3.90	.20	5.07	.26	6.26	.32	6.04	.31
Maximum	40.0	58168.0	Fully Loaded	4.85	1.65	0.08	1.45	.07	1.44	.07	2.67	.13	2.69	.13	2.68	.13
Normal	41.0	58820.0	3-Ft. Light	4.98	.80	0.04	3.02	.15	2.81	.14	2.81	.14	2.62	.13	2.61	.13
Maximum	41.0	63260.0	1-Ft. Light	4.71	.85	0.04	1.70	.08	1.49	.07	1.48	.07	1.50	.07	1.48	.07
Normal	42.0	63132.0	4-Ft. Light	4.86	.82	0.04	1.65	.08	1.65	.08	1.44	.07	1.40	.07	2.88	.14
Maximum	42.0	67908.0	2-Ft. Light	4.60	.87	0.04	1.74	.08	1.74	.08	1.52	.07	1.52	.07	1.52	.07
No Usage for Draft of 43.0 Feet																
No Usage for Draft of 44.0 Feet																
				TOTAL WEIGHTED COST =		6.50		6.21		6.06		5.82		5.76		5.69
Foreign Vessels																
No	32.0	24515.0	Fully Loaded	6.17	5.06	0.32	3.63	.23	1.72	.11	-	-	-	-	-	-
No	33.0	27310.0	Fully Loaded	5.86	7.15	0.43	5.31	.32	3.97	.24	-	-	-	-	-	-
No	34.0	30106.0	Fully Loaded	5.27	9.44	0.51	6.64	.36	5.69	.31	4.74	.26	3.29	.18	1.27	.07
No	35.0	33224.0	Fully Loaded	4.82	10.52	0.52	7.26	.36	7.03	.35	6.79	.34	5.79	.29	4.97	.25
No	36.0	36342.0	Fully Loaded	4.40	12.40	0.56	10.62	.48	10.34	.47	9.65	.45	9.62	.44	8.71	.40
No	37.0	39585.0	1-Ft. Light	4.15	8.22	0.35	8.67	.37	9.33	.40	8.82	.38	8.81	.38	9.46	.41
Normal	37.0	41073.0	Fully Loaded	4.07	7.41	0.31	7.17	.30	6.90	.29	7.34	.31	7.38	.31	8.00	.34
No	38.0	44021.0	2-Ft. Light	4.00	9.25	0.38	9.72	.40	10.40	.43	10.83	.45	10.59	.44	11.50	.48
Normal	38.0	47309.0	Fully Loaded	3.81	7.41	0.29	8.16	.32	8.89	.35	9.60	.38	10.36	.41	10.30	.41
No	39.0	48895.0	3-Ft. Light	3.80	3.84	0.15	4.86	.19	4.59	.18	6.58	.26	6.58	.26	6.30	.25
Normal	39.0	52855.0	1-Ft. Light	3.60	7.04	0.26	10.28	.38	11.29	.42	11.76	.44	12.83	.48	13.58	.51
Maximum	39.0	54835.0	Fully Loaded	3.50	4.18	0.15	4.17	.15	5.26	.19	6.05	.22	6.05	.22	6.02	.22
No	40.0	53748.0	4-Ft. Light	3.56	1.36	0.05	1.36	.05	1.35	.05	2.44	.09	2.43	.09	2.42	.09
Normal	40.0	57732.0	2-Ft. Light	3.39	1.43	0.05	2.87	.10	4.00	.14	5.11	.18	6.24	.22	6.22	.22
Maximum	40.0	61716.0	Fully Loaded	3.21	1.52	0.05	1.52	.05	1.51	.05	2.69	.09	2.69	.09	2.68	.09
Normal	41.0	62261.0	3-Ft. Light	3.24	0.91	0.03	3.00	.10	2.99	.10	2.68	.09	2.67	.09	2.66	.09
Maximum	41.0	66629.0	1-Ft. Light	3.07	0.95	0.03	1.58	.05	1.58	.05	1.57	.05	1.59	.05	1.56	.05
Normal	42.0	66453.0	4-Ft. Light	3.15	0.92	0.03	1.55	.05	1.54	.05	1.53	.05	1.53	.05	2.74	.09
Maximum	42.0	71181.0	2-Ft. Light	2.98	0.98	0.03	1.63	.05	1.62	.05	1.62	.05	1.62	.05	1.61	.05
No Usage for Draft of 43.0 Feet																
No Usage for Draft of 44.0 Feet																
				TOTAL WEIG'TED COST =		4.50		4.32		4 23		4.09		4.05		4.01

TABLE B-20

AVERAGE SAVINGS - PETROLEUM PRODUCT [1/]
CHARLESTON HARBOR - 40 FOOT PROJECT

	1985	1995	2005	2015	2025	2035
COASTWISE VESSELS [1/]						
35 Ft. Cost	7.93	7.93	7.93	7.93	7.93	7.93
40 Ft. Cost	6.50	6.21	6.06	5.82	5.76	5.69
40 Ft. Unit Savings	1.43	1.72	1.87	2.11	2.17	2.24
Projected Commerce (1000 tons)	3,288.0	3,853.9	4,751.2	4,779.7	4,795.8	4,837.7
Total Coastwise Savings ($1000)	4,701.8	6,628.7	8,884.7	10,085.2	10,406.9	10,836.4
FOREIGN VESSELS [1/]						
35 Ft. Cost	5.40	5.40	5.40	5.40	5.40	5.40
40 Ft. Cost	4.50	4.32	4.23	4.09	4.05	4.01
40 Ft. Unit Savings	.90	1.08	1.17	1.31	1.35	1.39
Projected Commerce (1000 tons)	1,693.8	1,985.4	2,447.6	2,447.6	2,447.6	2,447.6
Total Foreign Savings ($1000)	1,524.4	2,144.2	2,863.7	3,206.4	3,304.3	3,402.2
Total Savings	6,226.2	8,772.9	11,748.4	13,291.6	13,711.2	14,238.6

Total Average Annual Equivalent Benefits ($1000) 9,220.3

(Petroleum Products)

1/ Division between coastwise and foreign vessels based on information supplied by terminal operators on existing commerce.

TABLE B-21

TRANSPORTATION SAVINGS
PETROLEUM PRODUCTS
CHARLESTON HARBOR - 42 FOOT PROJECT

	1985	1995	2005	2015	2025	2035
			COASTWISE VESSELS			
35 Ft. Cost	7.93	7.93	7.93	7.93	7.93	7.93
42 Ft. Cost	6.07	5.93	5.73	5.49	5.39	5.32
42 Ft. Unit Savings	1.86	2.00	2.20	2.44	2.54	2.61
Projected Tonnage (1000 tons)	3,288.0	3,853.9	4,751.2	4,779.7	4,795.8	4,837.7
Total Savings ($1000)	6,115.7	7,707.8	10,452.6	11,662.5	12,181.3	12,626.4
40 Ft. Savings	4,701.8	6,628.7	8,884.7	10,085.2	10,406.9	10,836.4
Incremental Savings	1,413.9	1,079.1	1,567.9	1,577.3	1,774.4	1,790.0
Savings Allotted to Other Ports (½ Incremental Savings)	706.9	539.6	784	788.6	887.2	895.0
Total Charleston Harbor Coastwise Savings (Total Savings - Savings Allotted to Other Ports)	5,408.8	7,168.2	9,668.6	10,873.9	11,294.1	11,731.4
Total Foreign Savings	2,015.6	2.521.4	3,500.1	3,793.8	3,965.1	4,063.0
Total Charleston Harbor Savings	7,424.4	9,689.6	13,168.7	14,667.7	15,259.2	15,794.4

Average Annual Equivalent Benefit ($1000) . 10,394.35

TABLE B-22

ESTIMATED SAVINGS
PETROLEUM AND PETROLEUM PRODUCTS

Project Depth (Ft.)	Cargo Destination	Annual Savings ($1,000) 1985	1995	2005	2015	2025	2035	Average Annual Equivalent Benefit
				COOPER RIVER 1/				
35 to 38	Foreign	1,067.1	1,489.0	2,080.5	2,398.6	2,545.5	2,716.8	
	Coastwise	3,320.9	4,701.8	6,556.6	7,695.3	8,200.8	8,853.0	
	Total	4,388.0	6,190.8	8,637.1	10,093.9	10,746.3	11,569.8	6,700.6
35 to 40	Foreign	1,524.4	2,144.2	2,863.7	3,206.4	3,304.3	3,402.2	
	Coastwise	4,701.8	6,628.7	8,884.7	10,085.2	10,406.9	10,836.4	
	Total	6,226.2	8,772.9	11,748.4	13,291.6	13,711.2	14,238.6	9,220.3
35 to 42	Foreign	2,015.6	2,521.4	3,500.1	3,793.8	3,965.1	4,063.0	
	Coastwise	5,408.8	7,168.2	9,668.6	10,873.9	11,294.1	11,731.4	
	Total	7,424.4	9,689.6	13,168.7	14,667.7	15,259.2	15,794.4	10,394.4
				SHIPYARD RIVER 1/				
30 to 35	Foreign	174.5	192.2	221.8	221.8	221.8	221.8	
	Coastwise	1,020.6	1,123.3	1,296.6	1,306.0	1,311.1	1,324.8	
	Total	1,195.1	1,315.5	1,518.4	1,527.8	1,532.9	1,546.6	1,346.7
35 to 38	Foreign	71.4	93.6	122.4	141.1	149.8	159.8	
	Coastwise	383.2	509.5	665.2	781.6	833.4	901.3	
	Total	454.6	603.1	787.6	922.7	983.2	1,061.1	642.3
35 to 40	Foreign	102.0	134.8	168.5	188.6	194.4	200.2	
	Coastwise	542.5	718.3	901.3	1,024.4	1,057.6	1,103.2	
	Total	644.5	853.1	1,069.8	1,213.0	1,252.0	1,303.4	883.8
35 to 42	Foreign	134.8	158.5	205.9	223.2	233.3	239.0	
	Coastwise	624.1	776.8	980.8	1,104.5	1,147.8	1,194.3	
	Total	758.9	935.3	1,186.7	1,327.7	1,381.1	1,433.3	987.9

1/ Division between coastwise and foreign vessels based on information supplied by terminal operators on existing commerce.

for an indefinite period, but it can be expected to continue for several more years and then level off. The South Carolina State Ports Authority has been aggressive in its response to the demands of shipping interests and has provided more than adequate facilities and services. Rail and transportation facilities appear to be adequate to complement the mature ship-to-shore interface. A number of improvements have been made to the inland interface between trailers and rail facilities which will enhance the overall efficiency of the intermodal system.

CLASSIFICATION OF CONTAINERIZABLE PRODUCTS

26. A number of different attempts, including an origin-destination study, were made to project containerized cargo tonnage before the following method was derived. For years 1974 through 1977 the commerce for foreign imports and exports was extracted separately from "Waterborne Commerce of the United States". Coastwise commerce was not extracted because coastwise movements of containers in domestic trade do not exist. From the commodity classifications, the following items were deleted because they can be transported by bulk carriers and will never be containerized: all of Code 29 petroleum and related products, corn and soybeans, and aluminum and nonferrous ores. This is not to say that these are the only commodities that will not be containerized. Others will fall out as discussed below. Each commodity classification was analyzed individually and assigned a percentage containerizable by the following categories: prime, suitable, marginal, and unsuitable. These categories are defined as follows:

a. Prime. Generally commodities of high value, with relatively high shipping rates. Prime commodities possess those typical attributes which permit them to be efficiently packed in containers. Additionally, many commodities in this category are highly susceptible to damage or pilferage.

b. Suitable. Generally commodities of moderate value whose shipping rates are less than those for prime commodities. Suitable cargoes have only a modest susceptibility to damage or pilferage and possess a tendency to become contaminated or to incur penalty charges.

c. Marginal. Generally commodities that physically can be placed in containers, but are of low value with low shipping rates. Marginal commodities have little susceptibility to damage or pilferage. Some marginal cargoes would be difficult to containerize because of size, weight, or other packaging problems.

d. Unsuitable. Generally cargoes that physically cannot be placed in a container or normally are much more efficiently carried in specialized vessels and moved in large volumes.

27. Commodities were prorated on an individual basis by considering, where possible, the individual commodity and the trade route. Information contained in the Litton and Manalytics reports was used as a guide in determining these percentages. Once each commodity classification was prorated on a percentage basis to each of the four categories defined above, the tonnage was calculated for each commodity classification and then totaled. Table B-23 displays the distribution of percentage allocacations. Table B-24 summarizes the results of these computations, including the percentage of each category to the total tonnage.

PROJECTION OF CONTAINERIZED CARGO

28. Since 1964, foreign imports and exports other than bulk and petroleum products have had an annual growth rate of 6.4 percent. This compares with the annual growth rate of petroleum of 7.2 percent. Table B-25 shows the

TABLE B-23

TONNAGE FOR EACH COMMODITY CLASSIFICATION
CHARLESTON HARBOR - 1976
SAMPLE CALCULATION

EXPORTS

Code	Commodity	Percent				Tonnage			
		Prime	Suitable	Marginal	Unsuitable	Prime	Suitable	Marginal	Unsuitable
101	Cotton			100				12,960	
103	Corn				100				
105	Rice	75	25			910	303		
106	Sorghum Grains				100				
107	Wheat				100				
111	Soybeans				100				
112	Flaxseed		100				1		
119	Oil Seed				100				5,602
121	Tobacco	100				2,573			
122	Hay & Fodder		100				1,820		
129	Field Crops	75	25			556	185		
131	Fresh Fruits & (Field Nuts	100				835			
132	Bananas								
133	Coffee			100				2	
141	Fresh & Frozen Vegetables	75	25			907	302		
161	Animals & Products	95			5	2,985			157
191	Misc. Farm Products		50		50		3		2
841	Crude Rubber & Allied Gums	80	20			33	9		
861	Forest Products	65	35			137	84		
911	Fresh Fish	100				100			
1011	Iron Ore & Concentrates				100				
1051	Aluminum Ore				100				
1061	Mangense Ore				100				
1091	Non Fossil Ore				100				
1121	Coal & Lignite				100				
1311	Crude Petroleum				100				
1411	Limestone			25	75			45	146
1412	Building Stone			25	75				
1442	Sand, Gravel, Crushed Rock			25	75			208	622
1451	Clay			25	75			39,369	118,108
1479	Natural Fertilizer Mats	10	15	25	50				
1499	Non-Metallic Minerals	10	10	80		1,497	1,497	11,977	
1911	Ordnance & Accessories								
2011	Meat, Fresh, Chilled & Frozen	100				5,655			
2012	Meat & Products	95			5	254			15
2015	Animal By-Products	95	5			10,028			528
2021	Dairy Products								
2031	Fish & Shellfish	100				280			
2034	Vegetables & Prep.		100			7,081			
2039	Prep. Fruit & Vegetable Juice	100				25,903			
2041	Wheat Four & Semolina		100				1,424		
2042	Prepared Animal Feeds		100				3,870		

TABLE B-23 (Cont.)

TONNAGE FOR EACH COMMODITY CLASSIFICATION
CHARLESTON HARBOR - 1976
SAMPLE CALCULATION

IMPORTS

Code	Commodity	Percent				Tonnage			
		Prime	Suitable	Marginal	Unsuitable	Prime	Suitable	Marginal	Unsuital
101	Cotton		50	50			7,960	7,959	
103	Corn								
105	Rice								
106	Sorghum Grains								
107	Wheat								
111	Soybeans								
112	Flaxseed								
119	Oil Seed	10	90			2	19		
121	Tobacco		100				4,760		
122	Hay & Fodder		75	25			50	17	
129	Field Crops	60	20	20		58	20	19	
131	Fresh Fruits & Field Nuts								
132	Bananas		100				173,634		
133	Coffee		100				789		
141	Fresh & Frozen Vegetables		100				611		
161	Animals & Products		100				19,265		
191	Misc. Farm Products	60	20	20		283	95	94	
841	Crude Rubber & Allied Gums		80	20			2,548	637	
361	Forest Products			100				17,681	
911	Fresh Fish		100			27			
1011	Iron Ore & Concentrates								
1051	Aluminum Ore								
1061	Mangense Ore								
1091	Non Fossil Ore								
1121	Coal & Lignite								
1311	Crude Petroleum								
1411	Limestone								
1412	Building Stone	75		25		44	14		
1442	Sand, Gravel, Crushed Rock				100				35
1451	Clay	50	20	30		348	139	208	
1479	Natural Fertilizer Mats	65	10	25		3,318	511	1,276	
1499	Non Metallic Minerals	50	50			17,398	17,398		
1911	Ordnance & Accessories				100				
2011	Meat, Fresh, Chilled & Frozen	100				12,270			
2012	Meat & Products		100				1,183		
2015	Animal By-Products		100						
2021	Dairy Products	75	25			1,466	488		
2031	Fish & Shellfish	100				1,892			
2034	Vegetables & Prep.	60	40			3,021	2,014		
2039	Prep. Fruit & Vegetable Juice	100				2,907			
2041	Wheat Flour & Semolina								
2042	Prepared Animal Feed		100				80		

TABLE B-24

FOREIGN TONNAGE
CONTAINERIZABLE CARGO BY CATEGORY

Category	1973		1974		1975		1976		1977		1978 (Est.)	
	Tonnage	Percent	Tonnage	Percent	Tonnage	Percent	Tonnage	Percent	Tonnage	Percent	Tonnage	Percent
Imports												
Prime	330,358		300,193		269,342		418,357		298,300			
Suitable	231,867		255,976		231,297		344,451		326,391			
Marginal	43,852		60,928		57,929		70,680		417,554			
Unsuitable	238,169		220,977		157,033		154,276		488,451			
Subtotal	844,246		838,074		715,601		987,764		1,530,696			
Exports												
Prime	200,827		237,177		210,316		321,730		456,456			
Suitable	173,766		211,394		226,816		298,837		346,302			
Marginal	265,402		337,364		325,900		391,756		107,848			
Unsuitable	428,618		510,414		616,811		177,389		215,029			
Subtotal	1,068,613		1,296,349		1,379,843		1,189,712		1,125,635			
Total												
Prime	531,185	28	537,370	25	479,658	23	740,087	34	754,756	28	960,920	28
Suitable	405,633	21	467,370	22	458,113	22	643,288	30	672,693	25	856,442	25
Marginal	309,254	16	398,292	19	383,829	18	462,436	21	525,402	20	668,918	20
Unsuitable	666,787	35	731,391	34	773,844	37	331,664	15	703,480	27	895,639	27
Total	1,912,859	100	2,134,423	100	2,095,444	100	2,177,476	100	2,656,331	100	3,381,919	100

SOURCE: Derived from "Waterborne Commerce of the United States," 1966-1977, Department of the Army, Corps of Engineers.

TABLE B-25

FOREIGN COMMODITIES [1/]
1964-77

Year	Import (1000 Tons)	Export (1000 Tons)	Total (1000 Tons)	Annual Change
1964	534,493	531,673	1,066,166	--
1965	671,759	364,865	1,036,624	- 29,542
1966	824,893	373,482	1,198,375	161,751
1967	757,081	445,566	1,202,647	4,272
1968	918,005	608,963	1,526,968	324,321
1969	736,146	458,631	1,194,777	-332,191
1970	710,510	595,574	1,306,084	111,307
1971	1,118,877	670,918	1,789,795	483,711
1972	1,316,457	638,225	1,954,682	164,887
1973	1,230,750	820,189	2,050,939	96,257
1974	930,460	1,175,051	2,105,511	54,572
1975	713,163	976,654	1,689,817	-415,694
1976	993,934	1,223,893	2,217,827	528,010
1977	1,146,809	1,250,095	2,396,904	179,077

[1/] Does not include petroleum products, grain and ore.

SOURCE: "Waterborne Commerce of the United States," 1964-1977, Department of the Army, Corps of Engineers.

growth of this commerce from 1964 through 1977. This rapid growth is not expected to continue indefinitely; however, due to conservation measures dictated by rapidly increasing petroleum prices and the need for an expanding export trade in other commodities in order to bring about a favorable balance of payments. The future growth rate is expected to be at a faster rate than that projected for petroleum products.

29. Before projecting future commerce which would move by containerships, the average percentages and tonnages were analyzed and compared with those contained in the survey report. The rapid growth in the containerizable cargo tonnages was noted, along with the rates of growth for the different categories of containerizable cargo. During the 1973-1977 period, the average rate of growth for the prime, suitable, and marginal categories was about 11.4 percent per year. The three categories of potential containerized cargo, prime, suitable, and marginal were projected individually based on historical trends in these categories and checked by comparing previously derived projections for several individual commerce categories with these projections for reasonableness. The results are shown in Table B-26. The average projected growth rates for the three categories combined are 6.7% for 1977 to 1985 period, 4.4% for 1985 to 1995, 3.0% for 1995 to 2005, 1.6% for 2005 to 2015, 0.9% for 2015 to 2025, and 0.5% for the 2025 to 2035 period.

30. The percent of cargo expected to be containerized by category for future years is presented in Table B-27 and was utilized in adjusting the projected potential containerizable cargo summarized in Table B-26.

31. The projected containerized cargo tonnages by category for selected years summarized in Table B-28 were obtained by multiplying the potential containerizable cargo presented in Table B-26 and the appropriate percentage obtained from Table B-27. The growth indicators for these cargo tonnages are shown below:

	Base Year (1977)	1985	1995	2005	2015	2025	2035
Containerized Cargo	74	100	134	169	203	241	283

TABLE B-26

POTENTIAL CONTAINERIZABLE CARGO
(1,000 TONS)

Category	1985	1995	2005	2015	2025	2035
Prime	1,280	1,860	2,390	2,780	3,000	3,100
Suitable	1,090	1,595	2,010	2,360	2,590	2,700
Marginal	925	1,380	1,790	2,120	2,390	2,590
TOTAL:	3,295	4,835	6,190	7,260	7,980	8,390

TABLE B-27

PERCENT OF CATEGORY TO BE CONTAINERIZED

	1985	1995	2005	2015	2025	2035
Prime	95%	97%	100%	100%	100%	100%
Suitable	80%	85%	90%	90%	90%	90%
Marginal	60%	68%	75%	75%	75%	75%

TABLE B-28

FUTURE CONTAINERIZED CARGO TONNAGE
(000 TONS)

Category	1985	1995	2005	2015	2025	2035
Prime	1,216	1,804	2,390	2,780	3,000	3,100
Suitable	872	1,356	1,809	2,124	2,331	2,430
Marginal	555	938	1,342	1,590	1,792	1,942
TOTAL	2,643	4,098	5,541	6,494	7,120	7,472

32. The above analysis suggests that 62 percent of the potential containerizable cargo (total in B-28 divided by the total in B-26) will be containerized by 1985, reaching 76 percent by year 2005, and remain at that percentage for the remainder of the project.

33. It should be noted that while the definitions of the four categories are important in the above analysis, they become somewhat academic in practice. Once a commodity grouping is containerized on a given trade route, in all probability it will remain that way henceforth, thereby losing its identity and becoming simply containerized cargo.

CONTAINERSHIP VESSEL STUDIES

34. Prior to the advent of container vessels to the Charleston Harbor fleet, tankers and ore carriers were the only vessels requiring channel depths greater than the authorized 35-foot waterway. The development of true container vessels is a relatively recent development and the wealth of historical data documenting their development, growth, and establishing future trends does not exist as it did for tankers. However, due to the rapid development of this type of commerce in the past few years, data is becoming available documenting how best to utilize this new technology. At least one thing still seems to be the same as in the 1973 Charleston Harbor Report -- the low density of general cargo will tend to hold loaded drafts close to existing dimensions, and future ships will increase in length and width over those constructed in the early 1970's. Therefore, for the most part, the needs of the waterway and the forecasting of the future traffic were based on the experience of the recent past derived from data obtained from the "Charleston Harbor Pilots Association Log" and the State Ports Authority.

WORLD CONTAINERSHIP FLEET

35. The June 15, 1979 edition of "Marine Engineering Log International" magazine gives the world containership fleet as of April 1, 1979 as shown on Table B-29.

36. This includes only vessels of or greater than: 400 20-foot equivalent units for full containerships, a container capacity of 50 20-foot equivalent units (TEU's) for part container and, probably, those vessels built from 1969 on. The above enumerated containership fleet is sharply down from 741 vessels listed in 1972-73. However, the number of full, or pure, containerships increased from 311 in 1972-73 to 384, as of April 1, 1979 Table B-30 lists the future vessel deliveries.

37. To further expand on the full containership portion of the fleet is the tabulation, from the same source, in Table B-31.

CONTAINERSHIP FLEET USING CHARLESTON HARBOR

38. Charleston Harbor currently serves sixteen of the major containership lines. Over 100 different containerships visited this harbor during the calendar year 1977, according to data furnished by the South Carolina State Ports Authority. Table B-32 illustrates the ages and design drafts of the containerships utilizing the harbor during 1977.

39. Analysis of Table B-32 reveals that some 242 trips out of a total of 391, or 61 percent, were made by vessels with design drafts of 31 feet or less. Of these 242 trips, some 42 percent were made in vessels built since 1966. Another concentration of drafts occurs in the 35-foot to 37-foot range, which contains a total of 100 trips, or about 26 percent of the total. However, all of these trips were made in vessels built since 1966. Of these trips made in vessels constructed since 1971, 42 percent have been vessels of 31 feet or less design drafts and 46

TABLE B-29

WORLD CONTAINERSHIP FLEET

Ship Type	No.	Twenty-Foot-Equivalent Units
Full Container	384	474.011
Part Container	100	56,318
Container - RO/RO	114	96,327
Container - Barge	16	22,970
TOTAL FLEET	614	649,626

TABLE B-30

FUTURE CONTAINERSHIP DELIVERY

Ship Type	No.	Twenty-Foot-Equivalent Units
Full Container	113	151,927
Part Container	100	55,947
Container - RO/RO	89	81,202
Container - Barge	4	3,380

TABLE B-31

FULL CONTAINERSHIPS
WORLD FLEET

Full Containership Capacity - TEU's	Current Fleet No.	Current Fleet TEU's	Future Deliveries No.	Future Deliveries TEU's
400 - 699	74	40,477	8	4,486
700 - 999	72	59,817	18	14,850
1,000 - 1,499	135	162,196	27	31,027
1,500 - 1,999	64	111,083	59	99,114
2,000 - 2,999	32	79,418	1	2,450
3,000+	7	21,020	0	-
TOTALS	384	474,011	78	151,927

TABLE B-32

AGE AND SIZE DISTRIBUTION OF CONTAINERSHIP FLEET USING CHARLESTON HARBOR IN 1977 BY TRIPS

PERIOD CONSTRUCTED	30 ft & Under	31 ft	32 ft	33 ft	34 ft	35 ft	36 ft	37 ft	38 ft	39 ft & Over
1972-1977	43	19	12	3	-	27	-	41	1	2
1967-1971	40	-	7	2	2	28	4	-	-	8
1963-1966	1	1	-	-	-	-	-	-	-	-
1958-1962	15	-	-	3	-	-	-	-	-	-
1954-1957	20	-	-	-	-	-	-	-	-	-
1947-1953	12	-	-	-	-	-	-	-	-	-
1940-1946	38	53	-	-	-	-	-	-	-	9
TOTAL	169	73	19	8	2	55	4	41	1	19

SOURCE: Data supplied by South Carolina State Ports Authority.

percent have been vessels of 35- to 37-foot design drafts. This indicates a continued development of combinations of vessel usages plus a continuing specialization of vessel usages where conditions warrant of this rapidly evolving type of vessel.

40. It is concluded from the above that the containership fleet using Charleston Harbor in the future will tend to follow patterns established in the recent past; but, it is expected that the vessels will be used more efficiently than in the most recent past. It is noted that Table B-32 indicates that many of the newer vessels using the harbor have design drafts of less than 33 feet. These vessels are expected to comprise much of the fleet using the harbor during the early years of the project. However, it is expected that the majority of the containerized receipts and shipments at Charleston will be transported in vessels with a draft range of 34 to 37 feet and a deadweight tonnage range of about 28,000 to 40,000 tons. Table B-33 shows the distribution of container vessel sizes that can be expected if Charleston Harbor was deepened to 40 feet for the years 1985, 1995, 2005, 2015, 2025 and 2035.

CONTAINER BENEFITS

41. The estimated transportation savings for the movement of containerized cargo is based on the average one-way sailing distance of 2,404 miles for U. S. vessels and 5,838 miles for foreign vessels. These mileages were calculated from information on container tonnage, including its origin and destination, furnished by the State Ports Authority. In the interim review of report, the round trip distances were used to calculate the unit cost of transporting the container cargo: however, since these vessels return loaded, one-way distances will be used in this study. The amount of cargo carried in American and foreign vessels was also extracted from this information. It is expected that the project commerce will continue

TABLE B-33

CONTAINER FLEET
CHARLESTON HARBOR
40-FOOT PROJECT

Draft Range (Ft.)	DWT Range (Tons)	Percent of Traffic by Year					
		1985	1995	2005	2015	2025	2035
			U. S. Flag				
Under 31	15,400	60	43	31	25	23	17
31 to 33	15,400 to 20,000	36	41	47	48	46	44
33 to 35	20,000 to 28,000	4	16	22	27	31	39
			Foreign Flag				
Under 31	15,400	7	4	2	0	0	0
31 to 33	15,400 to 20,000	15	11	9	6	2	0
33 to 36	20,000 to 28,800	63	61	60	59	59	53
36 to 39	28,800 to 39,800	15	24	29	35	39	47

to be moved at the current ratio of 33 percent in U. S. and 67 percent in foreign vessels, respectively.

BASIC ASSUMPTIONS

42. The South Carolina State Ports Authority has stated that no additional container facilities will be located on the bank of the Cooper River and any commerce in excess of the capacity of these facilities will be handled at the Wando River facilities, which are currently under construction. In the 1973 Interim Review of Reports on Charleston Harbor, the capacity of these facilities was estimated at 1,300,000 tons. This figure seems extremely conservative since the existing facilities handled over 1,700,000 tons in 1978 and the 1979 totals are ahead of the 1978 figure by a substantial margin for the first five months. From June 1978 through May 1979 those facilities handled approximately 1,900,000 tons. Based on these statistics, it is assumed that the existing facilities have an estimated capacity of 2,000,000 tons. Since the Wando River extension will be considered in a separate report, benefits attributable to containerized cargo will be computed on the 2,000,000 tons which can be handled by the existing facilities on the Cooper River. The projected containerized commerce for selected base years and excess above the 2,000,000 tons to be handled on the Wando River are given in Table B-34.

CALCULATION OF CONTAINER BENEFITS

43. The method used for calculating container benefits is basically the same method used in calculating petroleum benefits as discussed in paragraphs 19 through 23 of this appendix. The variances to this method will be discussed in the following paragraphs.

TABLE B-34

PROJECTED CONTAINER TONNAGE REQUIRING NEW FACTILITIES

	1985	1995	2005	2015	2025	2035
Projected Commerce	2,643,000	4,098,000	5,541,000	6,494,000	7,123,000	7,472,000
Cooper River	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000
Wando River	643,000	2,098,000	3,541,000	4,494,000	5,123,000	5,472,000

44. The first variance comes in the information required for calculating the unit cost. One-way cost is used in lieu of round trip cost and actual average time in port was used in lieu of using the loading rate furnished by OCE. This time was determined by recording the time between port of call of numerous vessels which call on the port on a regular basis. Knowing the round trip distance and average vessel speed, the in-port time can be determined.

Time in Port = ((Time Between Call) - (Round Trip Distance ÷ Avg Speed)) ÷ 2

45. The average cargo carried by the containers for entire route is obtained from the information on vessels furnished by OCE. It was therefore assumed that the unit cost for each size vessel would be the same regardless of how many feet light the vessel transits the Charleston Harbor Waterway. Studies were made on how many times the container using Charleston Harbor came in fully loaded, 1-foot light, 2-feet light, etc. This information was used to determine how often these containers were required to use tidal advantage. The percent these vessels came in at the various loaded conditions were fairly consistent regardless of vessel size. The results of this study are shown in Table B-35.

46. A sample calculation utilizing a 27,400 DWT container under a foreign flag is shown in Table B-36. The average unit cost for the 35-foot project is shown in Table B-37, while the unit cost for the 40-foot project is shown in Table B-38. The transportation savings for a 40-foot project are derived in Table B-39. The estimated annual saving from container traffic at the various depths investigated for Charleston Harbor are shown on Table B-40.

TABLE B-35

PERCENT CONTAINERS USE CHARLESTON HARBOR
AT VARIOUS LOAD CONDITIONS

	Fully Loaded	Feet Light Loaded						
		1 Foot	2 Feet	3 Feet	4 Feet	5 Feet	6 Feet	> 6 Feet
Percent of Vessels	13	14	22	16	14	8	8	5

TABLE B-36

SAMPLE CALCULATION
CONTAINER UNIT COST

	Tidal Condition		
	Low Tide	Normal Tide	Spring Tide
Vessel Size - 27,400			
Foreign Flag			
Available Information			
Draft - 35 Ft.			
Time in Port (Hrs.) - 160			
In Port Cost ($/Hr.) - $1,211			
Rd. Trip Distance (N. Mi.) - 11,676			
Speed (Knots) - 22.5			
Cost at Sea - $1,662			
Tidal Advantage (Ft.)		2	4
Max. Delay (Hrs.)		9	10
Tidal Cycle (Hrs.)		12.5	12.5
Cargo Capacity (Short Tons) - 20,832			
Total Vessel Cost in Port (Time in Port x $/Hr.)			
Total in Port Cost (160 Hrs. x $1,211)	$193,760		
Total Vessel Cost at Sea ($\frac{\text{One-Way Distance}}{\text{Speed}} \times$ Unit Cost)			
Total Cost at Sea ($\frac{5,838}{22.5} \times \$1,662$)	$431,230		
Tidal Delay Cost (Avg. Delay x Hourly Cost at Sea)			
Average Delay		3.2	4
Delay Cost		$5,320	$6,650
Total Cost (Cost in Port + Cost at Sea + Delay Cost)			
Total Cost	$624,990	$630,310	$631,640
Unit Cost (Total Cost : Cargo Capacity)			
Total Unit Cost	30.00	30.26	30.32

TABLE B-37

AVERAGE COST - CONTAINER FLEET
CHARLESTON HARBOR
35-FOOT PROJECT

Vessel Draft	Vessel Size	Advantage	Cost	1985 Percent Commerce	1985 Weighted Cost	1995 Percent Commerce	1995 Weighted Cost	2005 Percent Commerce	2005 Weighted Cost	2015 Percent Commerce	2015 Weighted Cost	2025 Percent Commerce	2025 Weighted Cost	2035 Percent Commerce	2035 Weighted Cost
American Containerships															
27	12,000	None	42.50	7.04	2.99	3.20	1.36	1.21	0.51	-	-	-	-	-	
28	12,600	None	38.13	9.62	3.67	5.10	1.94	2.06	0.79	-	-	-	-	-	
29	13,300	None	34.74	12.59	4.37	9.81	3.41	9.24	3.21	8.21	2.85	7.31	2.54	5.69	1.98
30	14,200	None	32.35	23.93	7.74	20.85	6.74	18.78	6.08	18.22	5.89	16.21	5.24	14.19	4.59
31	15,400	None	29.79	33.73	10.06	31.68	9.44	29.84	8.89	28.94	8.62	25.68	7.62	23.10	6.88
32	17,200	None	28.25	6.21	1.75	7.90	2.23	10.63	3.00	11.34	3.20	14.13	3.99	15.70	4.43
		Normal	28.66	1.24	0.36	2.26	0.65	2.13	0.61	3.09	.89	3.03	0.87	2.94	0.84
33	20,000	None	26.54	4.22	1.12	5.12	1.36	6.03	1.60	8.18	2.17	9.15	2.43	10.01	2.65
		Normal	26.95	1.41	0.38	3.84	1.03	3.62	0.97	4.68	1.26	5.72	1.54	5.56	1.50
34	24,000	None	24.96	-	-	2.99	0.75	4.22	1.05	4.09	1.02	4.00	1.00	5.19	1.30
		Normal	25.35	-	-	1.49	0.38	2.81	0.71	4.09	1.04	4.00	1.02	3.89	0.99
		High	25.45	-	-	1.49	0.38	1.41	0.36	1.36	0.35	1.33	0.34	2.60	0.66
35	28,000	None	20.00	-	-	-	-	2.01	0.40	1.95	0.39	1.91	0.38	1.85	0.37
		Normal	20.32	-	-	2.13	0.43	4.02	0.82	3.90	0.79	3.81	0.77	5.56	1.13
		High	20.40	-	-	2.13	0.44	2.01	0.41	1.95	0.40	3.81	0.78	3.71	0.76
		TOTAL WEIGHTED COST =			32.44		30.54		29.41		28.87		28.52		28.08
Foreign Containerships															
30	14,200	None	39.98	5.71	2.28	4.35	1.74	3.65	1.46	2.36	0.94	1.74	0.70	-	-
31	15,400	None	36.89	6.44	2.38	5.61	2.07	4.80	1.77	4.00	1.47	2.62	0.96	1.92	0.71
32	17,200	None	35.80	6.32	2.26	6.20	2.22	5.30	1.90	4.41	1.58	3.61	1.29	3.54	1.27
		Normal	36.08	1.58	0.57	1.55	0.56	0.76	0.27	0.74	0.26	0.72	0.26	0.71	0.25
33	20,000	None	33.12	6.27	2.08	6.15	2.04	6.00	1.99	5.00	1.68	4.09	1.36	4.01	1.33
		Normal	33.40	2.69	0.90	2.63	0.88	2.57	0.86	2.50	0.84	2.46	0.82	2.41	0.80
34	24,000	None	30.97	9.41	2.92	9.22	2.86	9.01	2.79	6.81	2.11	7.64	2.37	7.49	2.32
		Normal	31.23	8.36	2.61	7.17	2.24	6.00	1.87	5.84	1.82	5.73	1.79	4.68	1.46
		High	31.30	3.14	0.98	3.07	0.96	3.00	0.94	2.92	0.91	2.87	0.90	2.81	0.88
35	27,400	None	30.00	8.10	2.43	7.94	2.38	7.76	2.33	8.62	2.59	8.46	2.54	9.33	2.80
		Normal	30.26	15.05	4.55	15.88	4.81	15.51	4.69	15.08	4.56	16.92	5.12	18.66	5.65
		High	30.32	12.73	3.86	12.48	3.78	12.19	3.69	11.85	3.59	12.69	3.85	13.48	4.09
36	28,800	None	29.43	1.24	0.36	1.21	0.36	1.19	0.35	2.31	0.68	2.26	0.67	2.22	0.65
		Normal	29.69	3.72	1.10	3.64	1.08	5.93	1.76	8.07	2.40	7.92	2.35	8.87	2.63
		High	29.75	1.24	0.37	2.43	0.72	3.56	1.06	4.61	1.37	5.66	1.68	5.55	1.65
37	30,600	None	28.72	1.31	0.38	1.28	0.36	1.25	0.36	1.22	0.35	1.19	0.34	1.17	0.34
		Normal	28.97	2.61	0.76	3.84	1.11	3.75	1.09	4.87	1.41	4.78	1.38	4.63	1.36
		High	29.03	1.31	0.38	1.28	0.37	2.50	0.73	3.65	1.06	3.58	1.04	3.51	1.02
38	34,000	Normal	29.01	2.07	0.60	2.71	0.79	3.97	1.15	3.86	1.12	3.79	1.10	3.71	1.08
		High	29.08	0.69	0.20	1.35	0.39	1.32	0.38	1.29	0.37	1.26	0.37	1.24	0.36
		TOTAL WEIGHTED COST =			31.97		31.72		31.44		31.11		30.89		30.65

TABLE B-38

AVERAGE COST - CONTAINER FLEET
CHARLESTON HARBOR
40-FOOT PROJECT

Vessel Draft	Vessel Size	Advantage	Cost	1985 Percent Commerce	1985 Weighted Cost	1995 Percent Commerce	1995 Weighted Cost	2005 Percent Commerce	2005 Weighted Cost	2015 Percent Commerce	2015 Weighted Cost	2025 Percent Commerce	2025 Weighted Cost	2035 Percent Commerce	2035 Weighted Cost
							American								
27	12,000	None	42.60	7.04	2.99	2.49	1.06	-	-	-	-	-	-	-	
28	12,600	None	38.13	9.62	3.67	4.96	1.89	1.33	.51	-	-	-	-	-	
29	13,300	None	34.74	12.59	4.37	7.95	2.76	6.7	2.33	5.04	1.75	4.21	1.46	2.00	.69
30	14,200	None	32.35	23.93	7.74	19.39	6.27	16.52	5.34	14.36	4.64	13.23	4.28	10.35	3.35
31	15,400	None	29.79	33.73	10.07	30.80	9.18	28.87	8.60	27.88	8.30	21.93	6.53	18.34	5.46
32	17,200	None	28.25	7.45	2.10	10.97	3.10	16.45	4.65	16.88	4.77	20.35	5.75	20.25	5.72
33	20,000	None	26.54	5.13	1.49	9.95	2.64	12.83	3.40	14.64	3.89	16.48	4.37	18.79	4.99
34	24,000		24.96		-	7.26	1.81	9.52	2.38	11.82	2.95	12.82	3.20	14.61	3.65
35	28,000		20.00		-	6.22	1.25	7.77	1.55	9.38	1.88	10.99	2.20	15.66	3.13
		TOTAL WEIGHTED COST =			32.43		29.96		28.76		26.18		27.79		26.99
							Foreign								
30	14,200	None	39.98	4.28	1.71	2.33	.93	1.14	.45	-	-	-	-	-	-
31	15,400	None	36.89	4.83	1.78	3.29	1.21	2.56	.94	1.24	.46	-	-	-	-
32	17,200	None	35.80	6.10	2.18	4.36	1.56	3.53	1.27	2.74	.98	1.34	.48	-	-
33	20,000	None	33.12	7.78	2.58	5.76	1.91	4.81	1.59	3.89	1.29	3.04	1.01	1.48	.49
34	24,000	None	30.97	22.18	6.87	20.16	6.24	18.70	5.79	15.41	4.77	15.06	4.66	10.33	3.20
35	27,400	None	30.00	35.72	10.71	35.08	10.53	35.20	10.57	37.19	11.14	37.28	11.19	37.18	11.15
36	28,800	None	29.43	7.16	2.11	11.37	3.35	13.29	3.91	17.18	5.06	17.84	5.25	19.38	5.70
37	30,600	None	28.72	3.78	1.09	7.20	2.07	8.18	2.35	10.20	2.93	11.08	3.18	12.91	3.71
		Normal	28.97	1.26	.36	1.20	.35	2.34	0.68	2.27	0.66	2.22	.64	2.15	.62
38	34,000	None	28.76	2.66	.77	3.81	1.09	3.71	1.07	3.59	1.03	4.68	1.35	5.69	1.64
		Normal	29.01	1.33	.39	1.27	.37	2.47	.72	2.40	.70	2.34	.68	3.41	.99
39	39,800	None	28.87	1.46	.42	1.39	.40	1.35	.39	1.31	.38	2.56	.74	3.74	1.08
		Normal	29.13	1.46	.42	1.39	.40	1.35	.39	1.31	.38	1.28	.37	2.49	0.73
		High	29.19		-	1.39	.41	1.36	.39	1.31	.38	1.28	.37	1.25	.36
		TOTAL WEIGHTED COST =			31.39		30.82		30.51		30.16		29.92		29.67

TABLE B-39

AVERAGE SAVINGS - CONTAINERSHIPS
CHARLESTON HARBOR
40-FOOT PROJECT

Item	YEAR 1985	1995	2005	2015	2025	2035
			Coastwise Vessels			
35 Ft. Cost	32.44	30.54	29.41	28.87	28.52	28.08
40 Ft. Cost	32.43	29.96	28.76	28.18	27.79	26.99
40 Ft. Unit Saving	.01	0.58	0.63	0.69	0.73	1.09
Projected Commerce (000 Tons)	650	650	650	650	650	650
Total Coastwise Savings ($ 000)	6.5	377	422.5	448.5	474.5	708.5
			Foreign Vessels			
35 Ft. Cost	31.97	31.72	31.44	31.11	30.89	30.65
40 Ft. Cost	31.39	30.82	30.51	30.16	29.92	29.67
40 Ft. Unit Savings	.58	.90	.93	.95	.97	.98
Projected Commerce (000 Tons)	1,350	1,350	1,350	1,350	1,350	1,350
Total Foreign Savings	783.0	1,215.0	1,255.5	1,282.5	1,309.5	1,323.0
Total Savings	789.5	1,592.0	1,678.0	1,731.0	1,784.0	2,031.5
Total Average Annual						1,384.4

TABLE B-40

ESTIMATED SAVINGS - CONTAINER CARGO
VARIOUS DEPTHS

Project Depth (Ft.)		Annual Savings ($1,000)						Average Annual Equivalent Benefit
		1985	1995	2005	2015	2025	2035	
38	U. S.	6.5	299.0	338.0	357.5	390.0	474.5	
	Foreign	391.5	553.5	621.0	702.0	972.0	1,053.0	
	Total	398.0	852.5	959.0	1,059.5	1,362.0	1,527.5	780.7
40	U. S.	6.5	377.0	422.5	448.5	474.5	708.5	
	Foreign	783.0	1,215.0	1,255.5	1,282.5	1,309.5	1,323.0	
	Total	789.5	1,592.0	1,678.0	1,731.0	1,784.0	2,031.5	1,384.4
42	U. S.	6.5	377.0	422.5	448.5	474.5	708.5	
	Foreign	796.5	1,228.5	1,269.0	1,309.5	1,323.0	1,350.0	
	Total	803.0	1,605.5	1,691.5	1,758.0	1,797.5	2,058.5	1,399.3

Dry Bulk Benefits

GENERAL

47. The third type of transportation savings from an improved harbor comes from the use of larger dry bulk carriers. These vessels are used to transport grain, chrome ore, and alumina. Grain and alumina are, or will be unloaded over facilities located adjacent to Cooper River while chrome ore is unloaded over facilities located on Shipyard River.

GRAIN

48. Grain export shipments from the port increased from 148,800 tons in 1964, a year after the bulk grain facility began operation, to 571,806 tons in 1976. The grain crop tributary area of the port is considered to be the state of South Carolina, although small export quantities come from North Carolina and Georgia. Statewide soybean production is expected to increase from about 21,139,900 bushels in 1970 to about 30,000,000 bushels in 1980, of which about 12,000,000 bushels would be available for export and within the capacity of world markets to absorb. State-wise, corn production is expected to increase from about 19,000,000 bushels in 1969 to 30,000,000 bushels in 1980 of which about 3,500,000 bushels would be available for export. The above estimates were derived from information furnished by Clemson University and the South Carolina Farm Bureau Marketing Association, the lessee and operator of the grain elevator. Based on increasing past utilization of the grain elevator and the apparent unlikelihood of future expansion of the existing facility by the South Carolina State Ports Authority, the future tonnage is expected to reach its maximum level of 460,000 tons by 1985 with no further increase in average tonnage.

CHROME ORE

49. The principal metallic ore being handled over port facilities at this time is chrome ore. The United States does not have a domestic supply of chrome ore and must depend on foreign sources for its supply.

During the recent past, a substantial percentage of the United States total imports of this important ore has been imported through Charleston Harbor. Finished products are also exported through the harbor. Small quantities of aluminum concentrates are also transported through the harbor at this time. However, Alumax, Inc., is presently building an aluminum reduction plant within a few miles of Charleston Harbor. This plant will import 385,000 tons of alumina per year from Australia by 1985. A bulk shipping port to serve this plant is being built between miles 13 and 14 of the Cooper River portion of Charleston Harbor.

50. Total future commerce in ores was estimated through the use of historical trends in ore commerce and then by use of BEA Indices of production of primary metals for the state of South Carolina, plus the ore tonnage brought in by Alumax, Inc., for purposes of comparison. Historically, growth during the entire period 1958 to 1967 has been at a rate of about 10 percent per year and the growth rate from 1967 through 1977 was at a level of about 6.25 percent per year. Projecting these trends into the future indicates an average growth rate of 2.7% per year from 1977 to 1985, 3.0% per year from 1985 to 1995, 2.0% per year from 1995 to 2005, and 1.0% per year from 2005 to 2035. In the second method, estimated future production from the primary metals sector, using state-wide projections from the previously cited "Projections, Economic Activity in South Carolina, Series E Population, December 1975", was used in conjunction with the additional tonnage generated by the new aluminum reduction plant. This additional tonnage in its entirety was added to tonnage obtained by use of the primary metals indicator for the year 1985 and gradually decreased so that by the year 2035 the only increase projected was for the primary metals indicator alone. Use of historical trend lines yields projected tonnage somewhat higher than the use of Bureau of Economic Analysis based indices alone, but lower than the total for the second method. Due to the scale of production of this plant, which when operational will account for an estimated 8 percent of the world's aluminum, this second method was deemed to be the more reasonable of the two methods. The indicators used to project the tonnage for future years are shown in Table B-41. Benefits are, however, only taken for that portion of the total commerce for which actual savings can be demonstrated to occur, as shown below.

TABLE B-41

INDICATORS USED IN PROJECTING ORE TONNAGE

	1974[1/]	1985	1995	2005	2015	2025	2035
Chrome Ore and Aluminum Concentrates:	65	100	122	143	168	191	218
Alumax Plant	0	100	100	100	100	100	100

1/ Indicators to be applied to base tonnage. Not applied to actual 1974 tonnage.

DRY BULK VESSELS

50. Use of dry-bulk vessels in the past has been largely restricted to Shipyard River. The main exceptions have been the shipments originating at the grain elevators located on the main waterway. With the new facilities for Alumax, more of these vessels will be utilizing the main waterway. The authorized Shipyard River project provides for a 30-foot depth, therefore, the waterway needs are based on vessel drafts of 26 feet or greater. However, this does not reflect the true nature of the waterway nor vessel utilization thereof. Shipyard River has a very high shoaling rate and must be dredged annually to a depth of 36 feet to restore project dimensions between dredging efforts. Vessel operators utilize available overdepth dredging to facilitate vessels whose drafts would normally preclude their use on a 30-foot waterway.

WORLD BULK CARRIER FLEET

51. A summary of the world bulk carrier fleet presented in "Lloyd's Register of Shipping Statistical Tables, 1977," is shown here as Table B-42 with the addition of percentage calculations. It is noted that there were, in 1977, a total of 4,313 ore and bulk carriers in the world fleet, an increase of 1,010 over the number shown in "Lloyd's Register of Shipping," November 1973. As can be seen in Table B-42, the DWT of these vessels reflect yearly increases with some 37.1 percent of the total tonnage in vessels less than five years old, and another 34.0 percent in vessels five to nine years old. This tabulation shows that there are no vessels listed over 30,000 DWT that are over 24 years of age. Since the expected service life of a vessel is usually in the range of 20 years, it is expected that there would be few vessels in service during the early years of the project from any of the "Divisions of Age" columns after the "10-14 years" column. In the last 25 years, there has been a continual development of larger vessels and, by 1973, vessels of 200,000 DWT were in service, though not in significant numbers even by 1978.

TABLE B-42

SIZE AND AGE OF ORE AND BULK CARRIERS

Divisions of Tonnage	Divisions of Age: 0--4 Years No.	0--4 Years Tons Gross	5--9 Years No.	5--9 Years Tons Gross	10--14 Years No.	10--14 Years Tons Gross	15--19 Years No.	15--19 Years Tons Gross	20--24 Years No.	20--24 Years Tons Gross	25--29 Years No.	25--29 Years Tons Gross	30 Years & No.	30 Years & Tons Gross	TOTAL No.	TOTAL %	TOTAL Tons Gross	TOTAL %
							WORLD TOTALS											
6,000- 6,999	16	105,482	6	37,685	7	45,776	23	152,277	6	39,488	1	6,752	12	80,039	71	1.6	467,499	0.5
7,000- 7,999	19	139,916	11	83,402	11	83,264	17	127,657	11	85,100	-	-	54	410,563	123	2.9	929,902	0.9
8,000- 9,999	54	516,235	79	742,102	66	617,626	63	572,745	20	177,497	6	55,873	65	572,975	353	8.2	3,255,053	3.2
10,000- 14,999	248	3,082,507	317	3,906,813	155	1,906,167	224	2,725,549	62	730,015	39	477,891	59	762,280	1,104	25.6	13,591,222	13.5
15,000- 19,999	381	6,554,858	339	5,787,396	233	3,995,152	90	1,546,125	24	389,189	12	204,363	9	144,657	1,088	25.2	18,621,740	18.5
20,000- 29,999	186	4,325,896	181	4,321,735	227	5,545,629	27	653,495	3	68,459	-	-	-	-	624	14.5	14,915,214	14.8
30,000- 39,999	203	6,961,431	115	3,909,779	89	3,093,811	10	338,565	3	102,721	-	-	-	-	420	9.7	14,406,307	14.3
40,000- 49,999	41	1,764,273	53	2,333,023	51	2,225,578	5	217,235	1	44,339	-	-	-	-	151	3.5	6,584,448	6.5
50,000- 59,999	26	1,500,641	57	3,171,690	14	749,538	-	-	-	-	-	-	-	-	97	2.2	5,421,869	5.4
60,000- 69,999	67	4,349,515	37	2,368,091	1	64,558	1	64,558	-	-	-	-	-	-	106	2.5	6,846,722	6.8
70,000- 79,999	36	2,678,294	31	2,321,400	-	-	-	-	-	-	-	-	-	-	67	1.6	4,999,694	5.0
80,000- 89,999	21	1,796,030	31	2,653,387	1	85,906	-	-	-	-	-	-	-	-	53	1.2	4,535,323	4.5
90,000- 99,999	10	931,746	11	1,031,805	-	-	-	-	-	-	-	-	-	-	21	0.5	1,963,551	1.9
100,000-109,999	2	205,470	-	-	-	-	-	-	-	-	-	-	-	-	2	0.1	205,470	0.2
110,000-119,999	6	698,792	7	822,731	-	-	-	-	-	-	-	-	-	-	13	0.3	1,521,523	1.5
120,000-129,999	7	878,569	3	379,728	-	-	-	-	-	-	-	-	-	-	10	0.2	1,258,297	1.2
130,000-139,999	4	531,916	-	-	-	-	-	-	-	-	-	-	-	-	4	0.1	531,916	0.5
140,000 & above	3	435,712	3	430,164	-	-	-	-	-	-	-	-	-	-	6	0.1	865,876	0.8
TOTAL	1,330	37,457,283	1,281	34,300,931	855	18,413,005	460	6,398,206	130	1,676,808	58	744,879	199	1,970,514	4,313		100,921,626	
% Total	30.8	37.1	29.7	34.0	19.8	18.3	10.7	6.3	3.0	1.6	1.4	0.7	4.6	2.0				

Note: Includes combined ore/bulk/oil carriers.

Source: "Lloyd's Register of Shipping Statistical Tables, 1977."

During the documented period, increases in draft have occurred due to increasing tonnage. A distribution of the world dry-bulk carrier fleet, historical and projected, is shown in Table B-43. Table B-44 is derived from a study made for the Office of Commercial Development of the U. S. Department of Commerce, Maritime Administration, with a report entitled, "Merchant Fleet Forecast of Vessels in U. S. - Foreign Trade," dated May 1978, by Temple, Barker & Sloane, Inc. Since the commerce through Charleston Harbor which uses dry-bulk and ore carriers is mainly in foreign trade, this report was judged to be particularly applicable to the present study.

DRY BULK FLEET USING SHIPYARD RIVER

52. Analysis of the "Charleston Harbor Pilots Association Log" and data supplied by the State Ports Authority revealed that there were 24 trips in 1977 on this waterway by dry-bulk vessels, 16 by breakbulk vessels, and 9 by tankers to those terminals handling predominantly non-petroleum bulk material.

According to "Waterborne Commerce of the United States, 1976," about 500,000 tons of commerce had been conducted at terminals on Shipyard River which were capable of handling these cargoes. Examination of the "Charleston Harbor Pilots Association Log" for 1977 revealed that about 62 percent of the tonnage over the waterways to the terminals mentioned above were in vessels with loaded drafts of 28 feet or more. Further examination of this data plus additional data furnished by the South Carolina State Ports Authority indicates that, during this same period of time, approximately 95 percent of the trips to these terminals were made by vessels with a design draft of 28 feet or more. Thus, much more commerce could be handled on this waterway by the same vessels if they were utilized closer to present capacities. It is noted that in 1972 there were 34 vessel trips enumerated over the waterway. Of these, 21 (81%) occurred with loaded vessel drafts of 28 feet or more.

TABLE B-43

WORLD DRY BULK CARRIERS

DISTRIBUTION AMONG SELECTED DWT GROUPS
BY TONNAGE AND PERCENTAGE

DWT Range	11,000-20,000		20,000-40,000		40,000-60,000		60,000-85,000		Over 85,000	
Draft Range	26-32		32-36		36-40		40-46		46-56	
Year	1,000 DWT	%	1,000 DWT	%	1,000 DWT	%	1,000 DWT	%	1,000 DWT	%
1956	1,400	50	960	35	200	7	220	8	-	-
1962	8,170	49	6,870	41	1,400	8	360	2	-	-
1964	9,040	39	11,100	47	2,750	12	510	2	-	-
1970	9,620	18	21,160	40	10,250	19	6,740	13	5,010	10
1985	10,860	14	26,500	34	17,500	23	15,950	21	5,880	8
2000	12,140	14	28,980	33	20,000	23	18,850	22	7,530	8

SOURCE: Historical data adapted from "A Statistical Analysis of the World's Merchant Fleets." U.S. Maritime Administration.

Projections based on data prepared by American Merchant Marine Institute.

TABLE B-44

DRY BULK CARRIERS

ATLANTIC COAST (U.S. FLEET MEDIUM FORECAST)

DWT RANGE (1,000)	1980			1985			1990			1995			2000		
	Draft (Ft.)	World Fleet (No.)	U.S. Fleet (No.)	Draft (Ft.)	World Fleet (No.)	U.S. Fleet (No.)	Draft (Ft.)	World Fleet (No.)	U.S. Fleet (No.)	Draft (Ft.)	World Fleet (No.)	U.S. Fleet (No.)	Draft (Ft.)	World Fleet (No.)	U.S. Fleet (No.)
1- 10	20	10	-	19	9	-	18	9	-	19	10	-	18	10	-
10- 20	30	38	-	29	28	-	29	24	1	28	22	1	26	16	1
20- 30	33	72	-	33	75	1	34	71	2	34	66	2	35	50	2
30- 50	37	68	-	37	72	1	37	69	2	37	70	3	37	70	3
50- 70	41	59	-	41	64	1	41	67	2	41	63	2	41	62	3
70-125	46	11	-	46	15	-	46	21	-	46	29	1	46	38	2
125-175	58	1	-	57	2	-	56	3	-	56	7	-	56	13	1
175 +	-	-	-	-	-	-	-	-	-	67	2	-	67	5	-

SOURCE: "Merchant Fleet Forecast of Vessels in U.S.-Foreign Trade," May 1978, Final Report, U.S. Department of Commerce, Maritime Administration.

53. Trends in loaded vessel drafts for Shipyard River are shown in Table B-45. This gives data for the 1965-1977 period. Table B-46 tabulates the 1977 dry-cargo vessel trips, design (maximum) draft, average draft, and percent of tonnage transported over the waterway to the terminals handling this type of commerce, as recorded in the "Charleston Harbor Pilots Association Log".

54. It is concluded from the above analyses of the recorded trips and drafts over the waterway during the recent past that the existing waterway is being utilized to its fullest practicable extent.

55. Discussions with the largest single user of dry-bulk vessels over the Shipyard River waterway in earlier studies had revealed:

(a) Their shipments had accounted for approximately 75 percent of the total waterway dry-bulk tonnage;

(b) Their imports originate at Russian, African, and Turkish ports with sufficient harbor or offshore depths to accommodate the largest vessels compatible with a 38-foot channel depth;

(c) Foreign imports, depending on the characteristics of the port, were loaded at dockside and/or at anchor in adjacent deep water;

(d) The local plant has sufficent expansion area for berthing and cargo storage facilities required to accommodate larger vessels;

(e) They would utilize the largest vessels available which could operate over the improved project depth. Data presented in "Waterborne Commerce of the United States - 1976" indicates that this user's share of the commerce had increased to about 84 percent of the dry-bulk commerce in 1976.

TABLE B-45

SELF-PROPELLED DRY BULK VESSEL FLEET USING SHIPYARD RIVER

Draft (Ft.)	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
						Inbound							
Less than:													
26	13	6	5	13	18	18	17	11	16	17	24	10	9
Equal to or greater than:													
26	21	27	24	31	16	28	23	21	18	25	29	16	26
27	17	25	22	31	13	28	22	19	16	22	27	15	23
28	16	22	19	26	13	24	22	17	16	20	24	14	22
29	15	15	12	15	8	20	21	17	16	17	21	14	20
30	11	9	7	8	5	14	18	14	15	15	19	11	12
31	4	7	3	4	4	9	13	8	11	12	12	9	5
32	2	3	1	0	1	3	5	5	9	2	5	2	2
33	0	1	0	0	1	2	3	1	5	0	0	2	2
Total Vessel Trips	34	33	29	44	34	46	40	32	34	42	53	26	35
						Outbound							
Less than:													
26	30	30	24	44	29	44	35	24	27	26	43	17	26
Equal to or greater than:													
26	4	5	4	0	4	3	4	5	7	14	10	5	7
27	4	5	4	0	2	3	3	4	6	12	8	4	7
28	1	5	1	0	0	3	2	2	4	12	7	2	6
29	1	1	0	0	0	1	2	2	2	7	4	2	6
30	1	1	0	0	0	0	2	1	1	6	3	1	3
31	0	0	0	0	0	0	2	1	1	3	1	1	1
32	0	0	0	0	0	0	1	0	0	0	0	1	0
33	0	0	0	0	0	0	1	0	0	0	0	1	0
Total Vessel Trips	34	35	28	44	33	47	39	29	34	40	53	22	33

Sources: "Waterborne Commerce of the United States," 1965-1977, Department of the Army, Corps of Engineers.

56. Based on the increasing availability of larger vessels, the past utilization of the existing project depth, past discussions with users of the waterway, recent discussions with the U. S. Department of Commerce, Maritime Administration, and judgment, it is expected that the majority of the dry bulk commerce of Shipyard River will be transported in vessels with a draft range of 33 to 38 feet and a deadweight tonnage range of 25,000 to 50,000 tons. Table B-47 shows the distribution of dry-bulk vessel size utilizing Shipyard River for a 38-foot project for the years 1985, 1995, 2005, 2015, 2025 and 2035.

DRY BULK FLEET UTILIZING CHARLESTON HARBOR

57. In recent years, there has been increasing use of the harbor by bulk vessels not also utilizing Shipyard River. As previously mentioned, much of this traffic has been to and from the grain elevator. Grain is expected to remain an important export commodity as the U. S. concentrates on the nation's balance of payments problems. Table B-48 shows recent, 1972 to 1977, trips by bulk and ore vessels through the harbor area, based on data furnished by the South Carolina State Ports Authority. It is noted that from 1975 on, there has been a marked increase in the number of dry-bulk and ore vessels using Charleston Harbor. Over half of these vessels in 1977 had drafts in the 32- to 36-foot range.

FUTURE DRY BULK AND ORE FLEET

58. Future usage of the harbor, exclusive of the Shipyard River Reach, will be largely determined by two factors. The first one, demand for grain, has shown up in historical data. The second factor, alumina for an aluminum reduction plant, will not be realized until the plant is completed in 1980 or 1981. This plant is expected to use about 385,000

TABLE B-46

DRAFTS OF VESSELS - 1977
SHIPYARD RIVER

Vessel Trips	Design (Maximum) Draft (Ft.)	Average Loaded Draft (Ft.)	Percent of Dry Cargo Commerce
7	Less that 26'	19' 07"	6.8
1	26' 00" to 27' 11"	26' 00"	2.4
18	28" 00" to 29' 11"	28' 00"	38.5
6	30' 00" to 31' 11"	28' 04"	16.3
4	32' 00" to 33' 11"	28' 02"	13.2
4	34' 00" to 35' 11"	30' 08"	17.6
1	36' 00" and over	24' 00"	5.2

Source: Data supplied by South Carolina State Ports Authority.

TABLE B-47

DRY BULK VESSEL SIZE
38-FOOT PROJECT - SHIPYARD RIVER

Draft Range (Ft.)	DWT Range (Tons)	Percent of Traffic by Year					
		1985	1995	2005	2015	2025	2035
28 to 31	15,600 to 22,800	42	32	21	12	5	3
32 to 35	22,800 to 33,500	53	57	62	66	70	70
36 to 38	33,500 to 42,000	5	11	17	22	25	27

TABLE B-48

Trips by Dry Bulk and Ore Vessels Using Charleston Harbor

Design Draft (Ft.)	1972	1973	1974	1975	1976	1977
to 25' 11"	3	3	2	12	4	4
26' 00"- 27' 11"	0	0	0	5	1	10
28' 00"- 29' 11"	5	0	0	7	5	15
30' 00"- 31' 11"	8	5	6	7	13	23
32' 00"- 33' 11"	6	16	11	15	35	42
34' 00"- 35' 11"	38	26	21	27	37	47
36' 00"- 37' 11"	9	10	12	9	16	13
38' 00"- 39' 11"	0	0	2	2	1	2
40' 00" and over	0	2	0	0	4	1
TOTAL	69	62	54	84	116	157

Source: Derived from data supplied by South Carolina State Ports Authority.

tons of alumina per year from Australia. According to the company officials, the alumina will be delivered about 12 times a year in ships of 30,000 to 40,000 DWT. These vessels will use port facilities to be built by the company itself. These facilities will probably be operated by the State Ports Authority. This bulk shipping port will be built on the upper end of the North Charleston Reach at about mile 13.5; will cost about $35 million, and will include a dock, wharf, silos, vaccuum loaders, conveyors, gantry cranes, and other bulk handling equipment. Vessels using these facilities will have drafts in the 34- to 38-foot range and are limited by the controlling depth at the port in Australia from where the alumina is shipped. Vessels engaged in grain commerce are expected to follow the established general trends for dry bulk vessels as a whole. The future drafts of these vessels will be limited by their need to be able to serve a variety of ports at different times of the year. Projections of vessel sizes using Charleston Harbor facilities only are presented in Table B-49.

DRY BULK SAVING

59. The cost per ton (unit cost) for dry bulk vessels was computed by the same method described for calculating the unit cost for petroleum and petroleum products. All bulk cargo is currently being shipped in foreign vessels. The chrome ore is being imported from Russia, a round trip distance of 12,000 miles; alumina is imported from Australia, a one-way distance of 11,100 miles, and the grain is exported to numerous ports, most to southern Europe for an average round trip distance of 8,500 miles. A sample calculation utilizing a 28,600 DWT dry bulk vessel loaded with grain is shown in Table B-50. The average unit cost for the 35-foot project and the 40-foot project is shown in Tables B-51 and B-52, respectively. The transportation savings for a 40-foot project are derived in Table B-53. The estimated annual savings from dry bulk traffic at the various depths investigated for Charleston Harbor are shown in Table B-54.

Total Benefits

60. Table B-55 shows the total transportation savings for Charleston Harbor and Shipyard River for the proposed 38-, 40-, and 42-foot projects.

TABLE B-49

DRY BULK VESSEL SIZE
40-FOOT PROJECT - CHARLESTON HARBOR

Draft Range (Ft.)	DWT Range (Tons)	Percent of Traffic by Year					
		1985	1995	2005	2015	2025	2035
Charleston Harbor, exclusive of Shipyard River and Alumax							
Under 31	20,000 and under	15	10	5	3	0	0
31 to 35	20,000 to 30,000	25	20	15	12	7	5
35 to 37	30,000 to 37,000	35	41	45	47	49	50
37 to 40	37,000 to 50,000	20	23	25	27	30	30
40 and over	50,000 and over	5	6	10	11	14	15
Alumax							
35 to 38	30,000 to 40,000	100	100	100	100	100	100

TABLE B-50

SAMPLE CALCULATION
DRY CARGO UNIT COST

	Fully Loaded	Light Loaded 1 Foot	2 Feet	3 Feet	4 Feet	Tidal Advantage Normal	Spring (High)
Vessel Size	28,600						
Available Information							
Draft	34 Ft. 1/						
IMF (Short Ton/Inch)	104.8 1/						
Loading Rate (Ton/Hr.)	150 2/						
In Port Cost ($/Hr.)	476 1/						
Distance (Nautical Miles)	8,500 1/						
Speed (Knots)	15 1/						
Cost at Sea	591 1/						
Tidal Advantage						3	3
Max. Delay (Hr.)						9	10
Tidal Cycle						12.5	12.5
Total Vessel Cost in Port (Cargo Capacity : Loading Rate x Cost/Hr.)							
Cargo Capacity	30,751	29,493	28,235	26,978	25,720		
(Dwt x 1.12 x .96) - (Ft. Light Loaded x IMF x 12)							
Time in Port							
(Cargo ÷ Rate) x 2	410	393	376	360	343		
Total In Port Cost	195,160	187,068	178,976	171,220	163,268		
(Time x Hourly In Port Cost)							
Total Vessel Cost at Sea (Distance / Speed x Hourly Cost at Sea)							
Time (Distance / Speed)	566.66						
Total at Sea Cost	334,900						
Tidal Delay Cost (Average Delay x Hourly Cost at Sea)							
Average Delay (Max. Delay / 2 x Tidal Cycle)						3.2	4
Delay Cost						1,891	2,364
Total Cost (Cost in Port + Cost at Sea + Delay Cost)							
No Tidal Advantage	530,060	521,968	513,876	506,120	498,168		
Normal Tidal Advantage	531,951	523,859	515,767	508,011	500,059		
Spring Tidal Advantage	532,424	524,332	516,240	508,484	500,532		
Unit Cost (Total Cost : Cargo Capacity)							
No Tidal Advantage	17.24	17.70	18.20	18.76	19.37		
Normal Tidal Advantage	17.30	17.76	18.27	18.83	19.44		
Spring Tidal Advantage	17.31	17.78	18.28	18.85	19.46		

1/ Furnished by OCE
2/ Grain Operator
3/ Tide Charts

TABLE B-51

AVERAGE COST - GRAIN
CHARLESTON HARBOR 35-FOOT PROJECT

TIDE CONDITION	DRAFT IN/FT	CARGO	LOADING CONDITION	UNIT COST $/Ton	1985 PERCENT COMMERCE	1985 WEIGHTED COST	1995 PERCENT COMMERCE	1995 WEIGHTED COST	2005 PERCENT COMMERCE	2005 WEIGHTED COST	2015 PERCENT COMMERCE	2015 WEIGHTED COST	2025 PERCENT COMMERCE	2025 WEIGHTED COST	2035 PERCENT COMMERCE	2035 WEIGHTED COST
Low	31.0	21612.0	Fully Loaded	20.58	.12	2.70	NOTE: Vessel Fleet for the 35-Foot Project is Assumed to Remain the Life of the Project									
Low	32.0	23429.0	1-Ft. Light	19.85	8.92	1.77										
Normal High	32.0	24515.0	Fully Loaded	19.31	.25	1.98										
Low	33.0	25261.0	2-Ft. Light	19.24	.34	2.95										
Normal High	33.0	27633.0	Fully Loaded	18.19	19.96	3.63										
Low	34.0	26978.0	3-Ft. Light	18.76	.10	0.77										
Normal High	34.0	29493.0	1-Ft. Light	17.77	7.82	1.39										
Maximum High	34.0	30751.0	Fully Loaded	17.31	3.52	0.61										
Low	35.0	29250.0	4-Ft. Light	18.28	.34	0.61										
Normal High	35.0	31936.0	2-Ft. Light	17.35	9.68	1.68										
Maximum High	35.0	34621.0	Fully Loaded	16.53	3.94	0.65										
				TOTAL WEIGHTED COST =		18.74		18.74		18.74		18.74		18.74		18.74

TABLE B-52

AVERAGE COST - GRAIN
CHARLESTON HARBOR - 40-FOOT PROJECT

TIDE CONDITION	DRAFT IN/FT	CARGO	LOADING CONDITION	UNIT COST $/Ton	1985		1995		2005		2015		2025		2035	
					PERCENT COMMERCE	WEIGHTED COST	PERCENT COMMERCE	WEIGHTED COST	PERCENT COMMERCE	WEIGHTED COST	PERCENT COMMERCE	WEIGHTED COST	PERCENT COMMERCE	WEIGHTED COST	PERCENT COMMERCE	WEIGHTED COST
Low	31.0	21612.0	Fully Loaded	20.58	4.52	0.93	3.75	.77	3.70	.76	2.42	.50	2.42	.50	2.42	.50
Low	32.0	24515.0	Fully Loaded	19.24	6.55	1.26	4.99	.96	4.22	.81	4.15	.80	2.75	.53	2.75	.53
Low	33.0	27633.0	Fully Loaded	18.12	9.05	1.64	7.24	1.31	5.53	1.00	5.46	.99	4.58	.83	4.64	.84
Low	34.0	30751.0	Fully Loaded	17.24	11.89	2.05	9.81	1.69	8.77	1.51	8.69	1.50	7.77	1.34	6.03	1.04
Low	35.0	34621.0	Fully Loaded	16.46	16.47	2.71	17.07	2.81	16.78	2.76	16.64	2.74	18.40	3.03	18.35	3.02
Low	36.0	35804.0	Fully Loaded	16.29	20.20	3.29	20.75	3.38	21.42	3.49	23.31	3.80	24.09	3.92	25.96	4.23
Low	37.0	39168.0	1-Ft. Light	15.94	8.16	1.30	10.23	1.63	11.18	1.78	11.09	1.77	10.97	1.75	10.91	1.74
Normal High	37.0	40643.0	Fully Loaded	15.66	8.43	1.32	10.61	1.66	10.42	1.63	10.34	1.62	11.37	1.78	11.36	1.78
Low	38.0	42014.0	2-Ft. Light	15.74	3.75	0.59	4.90	.77	4.78	.75	4.76	.75	4.70	.74	4.70	.74
Normal High	38.0	45158.0	Fully Loaded	15.17	5.34	0.81	5.21	.79	5.15	.78	5.14	.78	5.07	.77	5.00	.76
Low	39.0	44473.0	3-Ft. Light	15.76	1.34	0.21	1.27	.20	2.55	.40	2.53	.40	2.47	.39	2.47	.39
Normal High	39.0	47797.0	1-Ft. Light	15.21	2.83	0.43	2.76	.42	4.08	.62	4.07	.62	4.01	.61	4.01	.61
Maximum High	39.0	49459.0	Fully Loaded	14.95	1.47	0.22	1.41	.21	1.41	.21	1.40	.21	1.40	.21	1.40	.21
Low	40.0	47746.0	4-Ft. Light	15.75		0.										
Normal High	40.0	51290.0	2-Ft. Light	15.22		0.										
Maximum High	40.0	54835.0	Fully Loaded	14.73		0.										
			TOTAL WEIGHTED COST =			16.76		16.61		16.52		16.47		16.40		16.38

TABLE B-53

AVERAGE SAVINGS - DRY BULK COMMERCE
CHARLESTON HARBOR - 40-FOOT PROJECT

Item	1985	1995	2005	2015	2025	2035
			Grain			
35 Ft. Cost	18.74	18.74	18.74	18.74	18.74	18.74
40 Ft. Cost	16.76	16.61	16.52	16.47	16.40	16.38
Unit Savings	1.98	2.13	2.22	2.27	2.34	2.36
Projected Commerce (tons)	460,000	460,000	460,000	460,000	460,000	460,000
Total Savings	$ 910,800	$ 979,800	$1,021,200	$1,044,200	$1,076,400	$1,085,600
			Alumina			
35 Ft. Cost	16.48	16.48	16.48	16.48	16.48	16.48
40 Ft. Cost	15.26	15.01	14.80	14.72	14.58	14.53
Unit Savings	1.22	1.47	1.68	1.76	1.90	1.95
Projected Commerce (tons)	385,000	385,000	385,000	385,000	385,000	385,000
Total Savings	$ 469,700	$ 565,950	$ 646,800	$ 677,600	$ 731,500	$ 750,750

TABLE B-54

ESTIMATED SAVING
DRY BULK PRODUCTS

PROJECT DEPTH	TYPE CARGO	1985	1995	2005	2015	2025	2035	AVERAGE ANNUAL EQUIVALENT BENEFITS
				Cooper River				
38 Ft.	Grain	$ 575,000	$ 598,000	$ 607,200	$ 630,200	$ 657,800	$ 685,400	$ 599,260
	Alumina	$ 361,900	$ 450,450	$ 527,450	$ 585,200	$ 646,800	$ 581,450	$ 460,540
	Total	$ 936,900	$1,048,450	$1,134,650	$1,215,400	$1,304,600	$1,266,850	$1,059,800
40 Ft.	Grain	$ 910,800	$ 979,800	$1,021,200	$1,044,200	$1,076,400	$1,085,600	$ 977,360
	Alumina	$ 469,700	$ 565,950	$ 646,800	$ 677,600	$ 731,500	$ 750,750	$ 570,590
	Total	$1,380,500	$1,545,750	$1,668,000	$1,721,800	$1,807,900	$1,836,350	$1,547,950
42 Ft.	Grain	$1,186,800	$1,269,600	$1,334,000	$1,343,200	$1,407,000	$1,416,800	$1,270,260
	Alumina	$ 469,700	$ 565,950	$ 646,800	$ 677,600	$ 731,500	$ 750,750	$ 570,590
	Total	$1,656,500	$1,835,550	$1,980,800	$2,020,800	$2,138,500	$2,167,550	$1,840,850
				Shipyard River				
35 Ft.	Chrome Ore	$1,661,000	$1,864,500	$2,032,200	$2,180,800	$2,334,800	$2,384,200	$1,888,100
38 Ft. 1/	Chrome Ore	$ 577,500	$ 739,800	$ 891,000	$ 987,200	$ 995,500	$ 998,200	$ 753,880
40 Ft. 1/	Chrome Ore	$ 701,200	$ 915,800	$1,086,200	$1,102,800	$1,116,500	$1,127,500	$ 908,460
42 Ft. 1/	Chrome Ore	$ 701,200	$ 915,800	$1,089,000	$1,105,500	$1,119,200	$1,133,000	$ 909,410

1/ Does not include deepening to 35-feet.

TABLE B-55

ESTIMATED AVERAGE ANNUAL BENEFITS
($000)
TOTAL COMMERCE AT VARIOUS DEPTHS

Project Depth	Types of Commerce			
	Petroleum	Containerized	Dry Bulk	Total
		Cooper River		
38 Ft.	6,700.6	780.7	1,059.8	8,541.1
40 Ft.	9,220.3	1,384.4	1,548.0	12,152.7
42 Ft.	10,394.4	1,399.3	1,840.8	13,634.5
		Shipyard River		
35 Ft.	1,346.7	-	1,888.1	3,234.8
38 Ft.1/	642.3	-	753.9	1,396.2
40 Ft.1/	883.8	-	908.5	1,792.3
42 Ft.1/	987.9	-	909.4	1,897.3
		Total Waterway		
38 Ft.1/	7,342.9	780.7	1,813.7	9,937.3
40 Ft.1/	10,104.1	1,384.4	2,456.5	13,945.0
42 Ft.1/	11,382.3	1,399.3	2,750.2	15,531.3

1/ Savings derived in deepening Shipyard River to 35 feet not included.

APPENDIX C
ENGINEERING INVESTIGATIONS
DESIGN & COST ESTIMATES

APPENDIX C
ENGINEERING INVESTIGATIONS
DESIGN & COST ESTIMATES

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APPENDIX C

ENGINEERING INVESTIGATIONS DESIGN & COST ESTIMATES

Introduction

1. This section presents information pertaining to detailed estimates of first cost, investments, increased annual maintenance costs, and annual charges for considered plans to modify Charleston Harbor, South Carolina.

Engineering Design

GENERAL

2. Modifications considered in this report are designed in accordance with criteria contained in EM 1110-2-1607; U. S. Army Corps of Engineers, Committee on Tidal Hydraulics, Report Number 3; and Proceedings of the American Society of Civil Engineers; Journal of the Waterways, Harbors and Coastal Engineering Division.

CHANNEL DEPTHS

3. The design channel depth for the existing waterway and channel extensions is based on the static loaded drafts of the range of vessels expected to transit the waterway and consideration of the following required for safe vessel operation:

(a) Clearance. A vessel must have sufficient water under the keel to allow for safe and efficient maneuvering when operated under its own propulsion. Two feet of clearance are required for channels constructed in soft material.

(b) Squat and trim. A vessel in motion will squat or sink in the water, depending on: (1) the vessel speed; (2) distance between keel and channel bottom; (3) trim of the vessel, (4) cross-sectional area of the vessel, (5) whether the vessel is passing another large vessel, (6) location of the vessel relative to the channel centerline, and (7) general characteristics of the vessel. The trim of a vessel refers to the angle of the bottom of the vessel with respect to the water surface. Vessels are trimmed during loading so that a level keel can be established at a later period during the voyage as fuel and water are used. An allowance of two feet for squat and trim is used in this report.

(c) Tidal phenomena. Vessels using Charleston Harbor are able to take advantage of an average tide of 2.0 feet throughout the year and tides of 4.0 feet during a limited portion of the year.

(d) Loss in buoyancy. The lower density of freshwater relative to saltwater results in a loss of buoyancy as a vessel moves from the ocean into a sound or river. The brackish transition zone from fresh to saltwater is normally located between mile 21 and 23 which is well above the head of the authorized project. Therefore, no allowance is needed for vessels transiting the existing waterway.

(e) Channel-bottom material. Numerous borings and probings have been obtained indicating mixtures of clays, silts, sands and organic material overlying Cooper Marl. No additional clearance for hard material is considered necessary for existing and considered project elements.

(f) Wave action in entrance channel. Waves or swells are always present over ocean bars. Wave forces result in the vertical vessel motions of heave, pitch, and roll, and must be considered in determining the necessary ocean bar channel depth. The motion of heave raises and lowers the entire vessel with relation to the stillwater level. The motion of pitch alternately thrusts the bow and stern of the vessel above and below the stillwater level. The motion of roll alternately raises and lowers one side of the vessel with relation to the keel or bottom centerline of the vessel. An additional depth of two feet is considered necessary to allow for heave, pitch, and roll of large vessels over the ocean bar channel.

(g) Summary. Figure C-1 illustrates the criteria used in determining channel depth for Charleston Harbor.

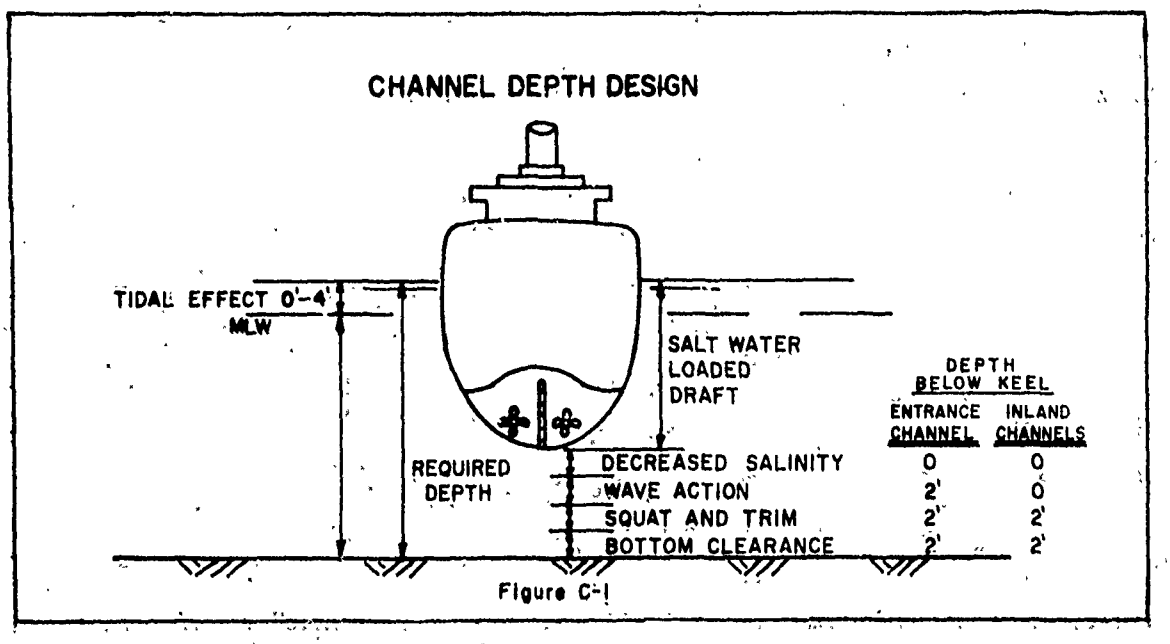


Figure C-1

CHANNEL WIDTHS

4. The design width of the Charleston Harbor channels is based on the traffic density, beam and steering characteristics of vessels expected to transit the waterway, and consideration of currents, wave conditions, winds, bends, and general alignment. Channel widths are measured at the design channel depth (bottom width).

5. The selected channel width must be sufficient to allow adequate control of vessels using the waterway under expected conditions of ship speed, currents, channel alignment and traffic. Consideration must be given to whether the waterway is unconfined, that is, in open water or restricted by adjacent banks. In an unconfined channel, the boundaries of the waterway are exterior to the channel boundaries and provide an open expanse of water beyond the channel. In a restricted channel, the boundaries of the waterway are the banks of the waterway. In addition, it is recognized that vessel maneuverability is affected by the combined channel dimensions, depth and width, and therefore must be considered jointly in selecting the proper waterway dimensions.

EFFECT OF RESTRICTED CHANNEL WIDTH

6. A vessel traversing the centerline of a waterway of limited width and depth will require frequent movement to correct for eddy action and small variations from course but are not of such magnitude as to result in vessel maneuverability and controllability problems. However, when a vessel deviates from the centerline or operates in an off-center portion of the channel close to one bank, a powerful side force and yawing (turning) motion are created and vessels are frequently moved from their expected course.

7. For a vessel in motion in stillwater, the water ahead of the vessel is moved forward, outward, and downward. A short distance aft of the bow, the water moves aft to make way for the body of this ship. The swiftest flow occurs amidships, and the elevation of the water surface in the vicinity of amidships is at its lowest. These changes in velocity result in changes in the water surface elevation in accordance with Bernoulli's theorem. More specifically, an asymmetrical flow distribution is developed on opposite sides of the vessel resulting in different water levels and unbalanced lateral forces to act on the ship. The water level

between the bow and near bank will build up above its normal level and tend to force the bow away from the near bank, thus turning the vessel towards the centerline of the channel. In addition, as the water flows aft to fill the void left by the ship, the current generated by the ship in the confined area between the hull and the near bank is greatly increased resulting in a drop in the water level and pressure forcing the stern towards the near bank. The effect of a passing vessel is to form an obstruction that accentuates the foregoing effects.

8. For one-way traffic, the channel width is divided into three parts: a vessel maneuvering lane, and a bank-clearance lane, on either side of the vessel, between the outer edges of the maneuvering land and adjacent channel bank. For two-way traffic, the channel width is divided into five parts consisting of the above and an additional vessel maneuvering land and clearance lane between vessels. The criteria used in determining channel widths needed to accommodate existing and expected vessels transiting the harbor is presented in Table C-1. Example applications are also presented for the largest of the most frequent vessels anticipated. The elements comprising a channel width are shown in Figure C-2.

9. After examining the criteria shown in Table C-1, it was determined that Charleston Harbor should be analyzed in six separate reaches considering the following factors:

(a) Size and speed of design vessels
(b) Density of vessel traffic
(c) Depth of channel
(d) Current, velocity and direction
(e) Vessel controllability on and off channel centerline
(f) Pilot experience and capability
(g) Channel uniformity and sinuosity

TABLE C-1

COMPUTATION OF CHANNEL WIDTH

MANEUVERING LANES

Criteria	Vessel	Beam Ft.	APPLICATION 160% of Beam	180% of Beam	250% of Beam
:quired width is 160% to)0% of the beam depending ı its controllability in ıe inner channels and ·0% of beam in the entrance ıd outer bar channels.	Container	110	-	200	275
	Tanker	100	-	180	250
	Dry Bulk	80	128	144	200

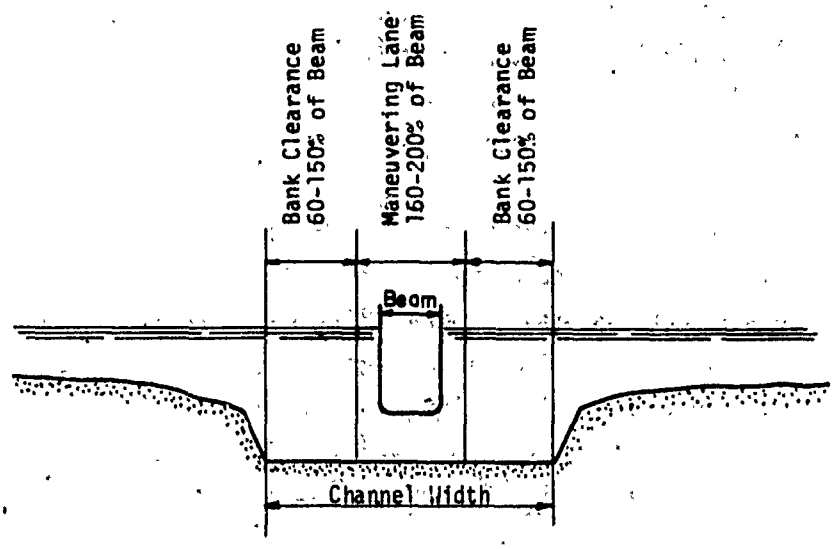
SHIP CLEARANCE LANE

Criteria		Example Application
100% of the beam when waterway is restricted or subject to strong yawing forces. In channels that are well buoyed and not subject to strong yawing forces, a width equal to 80% of the beam.	Case 1	Restricted waterway; two container vessels likely to pass in jetty channel ship clearance should be 100% of beam.
	Case 2	Channel is in a wide waterway and is well buoyed; large container vessels are likely to meet loaded tankers. Clearance lane should be 80% of beam.

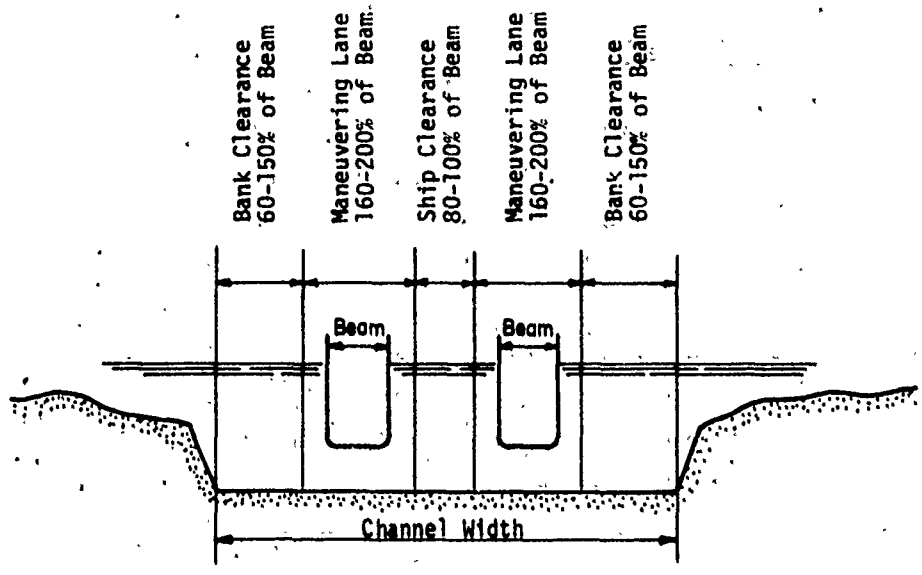
BANK CLEARANCE

150% of the beam of the design vessel in channels where there are strong yawing forces, or where the material beyond the channel limits is rocky or hard sands or gravels. 80% of the beam where the edges of the channel are subject to recurring shoaling. Minimum width is 60% of the beam where these conditions do not exist and the vessel is known to handle well that close to the edge of the channel.	Case 1	Two large container vessel to meet in jetty channel. Provide bank clearance lane of 150% of beam.
	Case 2	Channel subject to frequent shoaling at edges. Large tanker likely to meet large container. Provide bank clearance of 80% of beam.
	Case 3	Container vessel likely to meet a large tanker. Channel is not in heavy shoaling area. Provide bank clearance lane of 60% of beam.

ELEMENTS OF CHANNEL WIDTH



ONE-WAY TRAFFIC



TWO-WAY TRAFFIC

FIGURE C-2

(h) Length of channel
(i) Wind direction, velocity, and frequency
(j) Wave action and frequency
(k) Fog severity, duration, and frequency
(l) Available aids to navigation
(m) Obstacles to navigation
(n) Daytime and nighttime passage

The six reaches studied separately are the entrance channel (mile 0.8 seaward); mile 0.8 to the Custom House Reach, (mile 5.5); Custom House Reach to the North Charleston Reach (mile 12.8); North Charleston Reach to head at navigation (mile 15.6); Town Creek Reach and Shipyard River. The authorized channel widths for each of these reaches were analyzed to determine their adequacy to handle the vessels expected to use Charleston Harbor during the project life. Authorized and considered widths are summarized in Table C-2.

ENTRANCE CHANNEL

10. The entrance channel is subject to tidal currents, rough seas, breaking waves, wind and other difficulties. Control is difficult for large vessels as well as small boats entering the harbor. The relatively long length of this channel (12 miles) makes it imperative that two-way traffic be maintained. Vessel studies indicate that frequent passing of two large container vessels can be expected; therefore, this is assumed to be the design condition. Vessel studies indicate that two of the largest vessels expected to transit the harbor channels - containerships with 110-foot beams, will pass in the entrance channel. Based on 150% beam for bank clearance, 250% beam for maneuvering land and 100% beam for ship clearance, a 990-foot width would be required (see Figure C-3). Therefore, the existing 1000-foot width is adequate.

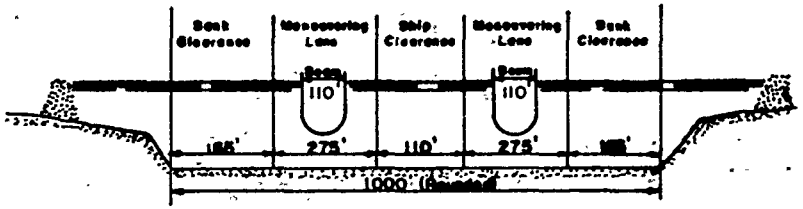
TABLE C-2

AUTHORIZED AND CONSIDERED PROJECT WIDTHS

SECTION OF WATERWAY	AUTHORIZED WIDTH	CONSIDERED WIDTH	INCREMENTAL CHANGE	LENGTH OF CHANNEL (MI
ENTRANCE CHANNEL				
Fort Sumter Range	1,000'	1,000'	-	9.87
Mount Pleasant Range	1,000'	1,000'	-	0.85
CHARLESTON HARBOR (Mi. 0.8 to Wando River)				
Mount Pleasant Range	600'	600'	-	0.94
Rebellion Reach	600'	600'	-	2.17
Folly Reach	600'	600'	-	0.62
Shutes Reach	800'	800'	-	0.34
Horse Reach	800'	800'	-	0.49
Hog Island Reach	600'	600'	-	1.62
Custom House Reach	Vary	Vary	-	0.33
Town Creek:				
Upper	500'	400-500'	0'to -100'	1.23
Lower	500-800'	400-1,200'	-100'to +400'	1.02
Tidewater	700'	630'	-70	.82
WANDO RIVER UPSTREAM TO NORTH CHARLESTON REACH (Mi. 12.6)				
Drum Island Reach	600'	600'		.96
Myers Bend	800'	800'		.55
Daniel Island Reach	600'	600'		1.20
Daniel Island Bend	700'	700'		0.65
Clouter Creek Reach	600'	600'		1.07
Navy Yard Reach	600-800'	600-800'		1.26
NORTH CHARLESTON REACH TO HEAD OF NAVIGATION (Goose Creek)				
North Charleston Reach	400-600'	500'	-100'to +100'	1.18
Filbin Creek Reach	400'	500'	+100'	.68
Port Terminal Reach	700-1,100'	575-1,200'	-125'to +100'	0.80
Ordnance Reach	400'	275'	-125'	0.37
Shipyard River:				
Entrance Channel	300'	300'		.53
Basin A	800'	1,150'	+350'	.15
Connector Channel	200'	250'	+50'	.55
Basin B	600-700'	880-1,050'	+280'to +350'	.17

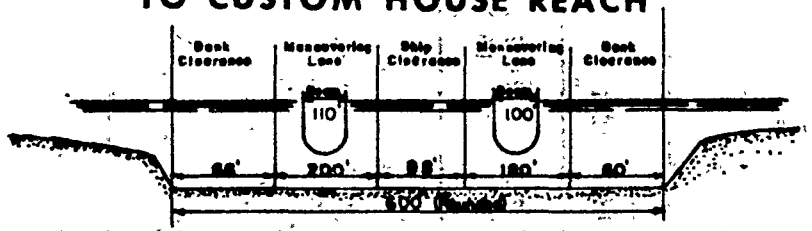
CHANNEL WIDTHS

ENTRANCE CHANNEL (Mi 0.8 SEAWARD)



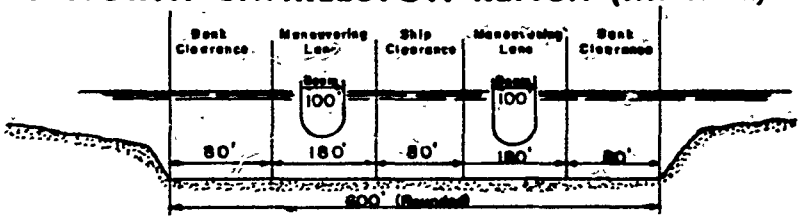
DESIGN BASED ON THE LIKELY PASSING OF TWO FULLY LOADED 110-FT BEAM CONTAINER VESSELS

CHARLESTON HARBOR (Mi 0.8) UPSTREAM TO CUSTOM HOUSE REACH



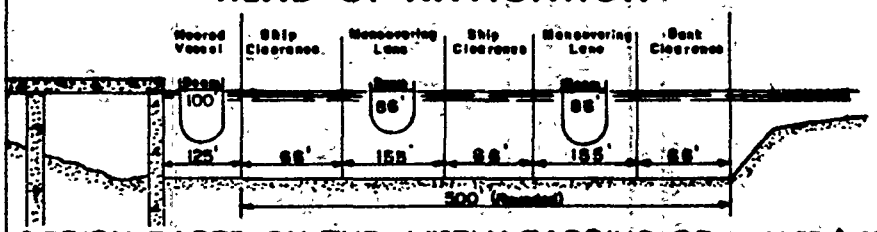
DESIGN BASED ON THE LIKELY PASSING OF FULLY LOADED 110 FT BEAM CONTAINER VESSEL AND 100 FT BEAM TANKER

CUSTOM HOUSE REACH TO NORTH CHARLESTON REACH (Mi 12.6)



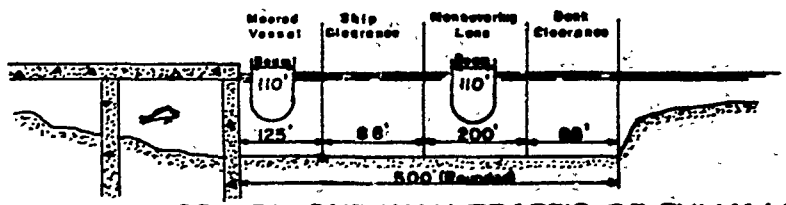
DESIGN BASED ON THE LIKELY PASSING OF 100 FT BEAM CONTAINER VESSEL AND FULLY LOADED 100 FT BEAM TANKER IN PARTIALLY RESTRICTED WATERWAY

NORTH CHARLESTON REACH TO HEAD OF NAVIGATION



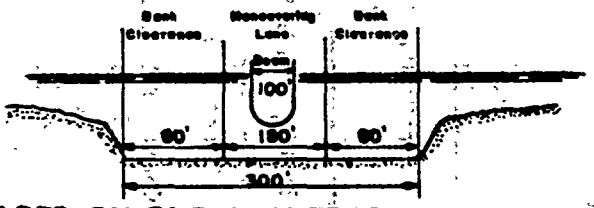
DESIGN BASED ON THE LIKELY PASSING OF AN 80FT & 90FT BEAM CONTAINER VESSELS IN RESTRICTED WATERWAY

TOWN CREEK REACH



DESIGN BASED ON ONE-WAY TRAFFIC OF FULLY LOADED 110 FT BEAM CONTAINER IN PARTIALLY RESTRICTED WATERWAY

SHIPYARD RIVER (ENTRANCE CHANNEL)



DESIGN BASED ON ONE-WAY TRAFFIC OF FULLY LOADED 100 FT BEAM TANKER IN PARTIALLY RESTRICTED WATERWAY

FIGURE C-3
R-11-20-80

ENTRANCE CHANNEL TO CUSTOM HOUSE REACH

11. The authorized channel in this reach is 600 feet in straight reaches and 800 feet in bend and congested area. Channels are primarily in open water unlike the jettied entrance channel and experience little shoaling. This 4.7 mile reach has the largest traffic density of the entire waterway. Vessel studies for existing and future traffic in this reach indicate the likely passing of two vessels with beams of 110 and 100 feet respectively, (see Figure C-3), or two 107-foot beam vessels. The existing widths are considered adequate.

CUSTOM HOUSE REACH TO NORTH CHARLESTON REACH

12. The authorized channel in this reach is 600 feet in straight reaches and 700-800 feet in bends and congested areas. Traffic in this reach decreases in an upstream direction due to vessels utilizing Town Creek, Shipyard River and various Navy facilities along the waterway. Heavy shoaling occurs along the edges at various locations within this 7.3 mile reach. The design criteria for this reach would therefore be 80% beam for bank clearance, 180% beam for maneuvering land and 80% beam for ship clearance. Based on this criteria, and vessel studies indicating the likely passing of two 100-foot beam vessels (see Figure C-3) or a 110-foot beam vessel and an 86-foot beam vessel, the existing widths are adequate to meet the needs for existing and expected future traffic.

NORTH CHARLESTON REACH TO HEAD OF PROJECT

13. This 2.8 mile reach of waterway contains two sub-reaches, each a little over 3,000 feet long, currently authorized and maintained to a width of 400 feet. Known as the North Charleston Reach and the Filbin Creek Reach, they are located along "tanker row". Here many of the docks touch the

authorized channel. When a tanker is moored to these docks, it is in the channel, thereby reducing the effective channel width to less than 300 feet. Complaints have been received from the Navy, Coast Guard, and the Charleston Harbor Pilots about this hazardous condition. Based on a required clearance of 80% beam between a moored tanker and a passing vessel, 180% beam for maneuvering lane and 80% beam for bank clearance, the existing channel is safe for one-way traffic for a vessel with a 80-foot beam. This channel is therefore considered inadequate for existing and prospective traffic which includes 110-foot beam container vessels and 100-foot beam tankers. Based on the criteria listed above, one-way traffic for a 110-foot beam container vessel would require a channel width of 374 feet. This reach of the waterway is utilized by commercial and naval vessels. Pilots controlling commercial vessels are in continuous radio contact with other pilots and could operate a one-way traffic pattern even though costly delays would result. The arrivals and departures of Navy vessels are not known and radio contact is not made until the vessels are sighted and then contact is limited for security purposes. Therefore, in the interest of safety and national defense two-way traffic should be maintained.

Analysis of the existing and expected vessel traffic indicates two 86-foot beam vessels are likely to pass in this reach (see Figure C-3) and would require 500-foot width. Therefore, the existing channel will be widened an additional 100 feet. Also, in the interest of safety, the effective channel width in this reach can be significantly improved by shifting the channel riverward to provide 125 feet clearance between the edge of the channel and docks. These modifications would provide a clear channel width of 500 feet at all times as opposed to the less than 300 feet when vessels are presently moored in the reach.

14. The existing turning basin at North Charleston has a turning diameter of 1,100 feet. Whenever a vessel is moored at the North Charleston terminal, this turning diameter is reduced to 975 feet, which is sufficient to turn a vessel safely with a length of 650 feet. Vessels with lengths up to 800 feet in length can be expected to regularly use this upper reach of the waterway. The design criteria for this turning basin is 150% of the vessel beam or in this case 1,200 feet. This design is illustrated in Figure C-4.

DESIGN OF TURNING BASINS

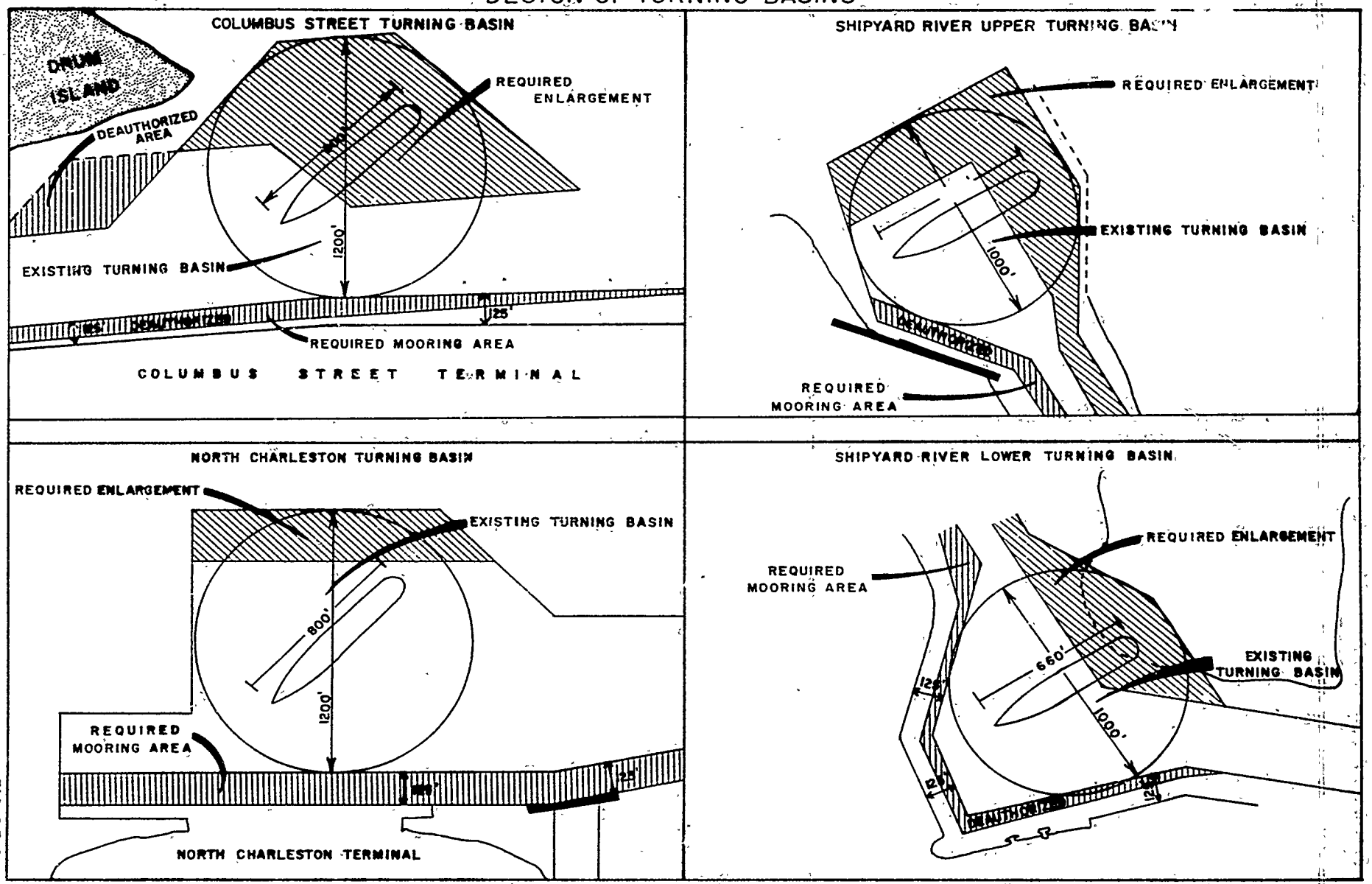


FIGURE C-4

TOWN CREEK REACH

15. The 3.2 mile Town Creek Reach varies in width from 500 to 700 feet. This channel separates from the main waterway at mile 5.5, and is used primarily by vessels calling at the South Carolina State Ports Authority docks. Most of the docks in the reach touch the authorized channel, which in effect reduces the usable width of the channel when a vessel is moored. This reach is relatively short, used by vessels entering with tug assistance, from the south and rarely used by thru traffic. Based on the anticipated frequency of use, one-way traffic for a 110-foot container is considered appropriate. Based on the criteria of 80% beam between moored and passing vessels, 180% beam for maneuvering and 80% for bank clearance, a channel width of 376 feet is computed as being required; therefore, the existing channel widths are considered adequate for the prospective traffic expected to use this reach of the waterway. The existing Federal channel width in this reach extends to the edge of existing docks. Vessels presently moored in this reach extend into the Federal navigation channel by necessity. Therefore, the existing channel centerline should be relocated riverward to provide a clear 125-foot berthing area between the channel edge and docks. After DE authorization of this 125-foot width, the remaining Federal channel will be of sufficient width to meet the needs of one-way traffic previously discussed. The existing 800-foot wide turning basin is considered inadequate for the larger container vessels with 800-foot lengths which can be expected at the Columbus Street dock. A turning area of 1,200 feet is required, considering a width of 1.5 times the vessel length as shown on Figure C-4.

SHIPYARD RIVER

16. The Shipyard River Project extends into Charleston Harbor at mile 8.8. The entrance channel to the lower turning basin in Shipyard River is 300 feet wide while the connecting channel to the upper turning basin is 200 feet wide. Currently vessel traffic on Shipyard River is restricted to one-way traffic, and inbound and outbound vessels are always under tug assistance. Review of the projected commerce and vessel fleet for Shipyard River demonstrates the 300-foot entrance channel serving one-way traffic is sufficient for existing and future conditions. Discussions with operators of the petroleum facility located on Shipyard River revealed that the vessels serving their facility

(660-foot long tankers) would not significantly increase in size as the available docking space and onloading facility are limiting factors.

The entrance channel has a history of low maintenance, therefore, the design criteria is based on 60% beam for bank clearance and 180% for maneuvering lane. This would allow one-way traffic for vessels with 100-foot beams (see Figure C-3). Vessels with beams greater than 100 feet are not anticipated to frequent Shipyard River because of the previously discussed docking and unloading facility limitations. The maximum beam vessel anticipated in the prospective vessel traffic using the upper turning basin is 80 feet. Vessels transiting the connecting channel will be in a protected area proceeding under control of tugs, therefore, 80% beam is considered sufficient between moored vessels and the passing vessel, 160% beam for maneuvering lane and 60% beam for bank clearance. The connecting channel based on this criteria, will be widened to 250 feet. The turning basins are considered inadequate for prospective vessel traffic, which includes vessels 660 feet in length. As a minimum, a 1,000-foot turning diameter is required as shown on Figure C-4.

ANCHORAGE BASIN

17. This basin is located at the South Channel intersection at mile 2.0. The basin is 2,200 feet wide and 7,400 feet long. It is laid out for free-swinging, single-point mooring. The Charleston Harbor Pilots have stated that this basin is not large enough for the larger vessels currently using the waterway and often times the vessel will protrude into the existing navigation channel. The deepening of the waterway will allow larger vessels to use the waterway, thus causing this occurrence to increase. The Corps criteria of the chain length being approximately six times the channel depth does not apply to this anchorage basin because of the strong currents and a silt bottom. Experience by the Charleston Harbor Pilots has shown that a minimum of a 360-foot chain length is required even for the smaller vessels using the anchorage basin. For the larger vessels with lengths of 860 feet, chain lengths of 540 feet are required while an 800-foot vessel would require a chain length of 450 feet. This criteria was backed by a report of a committee of the Maritime Association concerning anchorages in Charleston

Harbor. Based on this criteria, the existing anchorage basin is sufficient for two vessels 740 feet in length as shown in Figure C-5. The proposed enlargement would provide for a single vessel 860 feet in length or two vessels having lengths of 800 and 600 feet in length, respectively. The use of permanent moorings was also investigated; however, this proved to be an expensive alternative since this method would create the need for tie-up crews and for the use of tugs. This cost is conservatively estimated at $500,000 annually.

Subsurface Investigations

PURPOSE AND SCOPE

18. Comprehensive subsurface investigations in the vicinity of Charleston Harbor were deemed necessary for use in the decision-making process covered by this report. These investigations were necessitated because of the lack of sufficient soils information to determine a reliable estimate of first cost for dredging the proposed channel enlargements. The presence of Cooper Marl will increase the unit cost of initial dredging over that normally experienced when dredging silt and sand during maintenance operations.

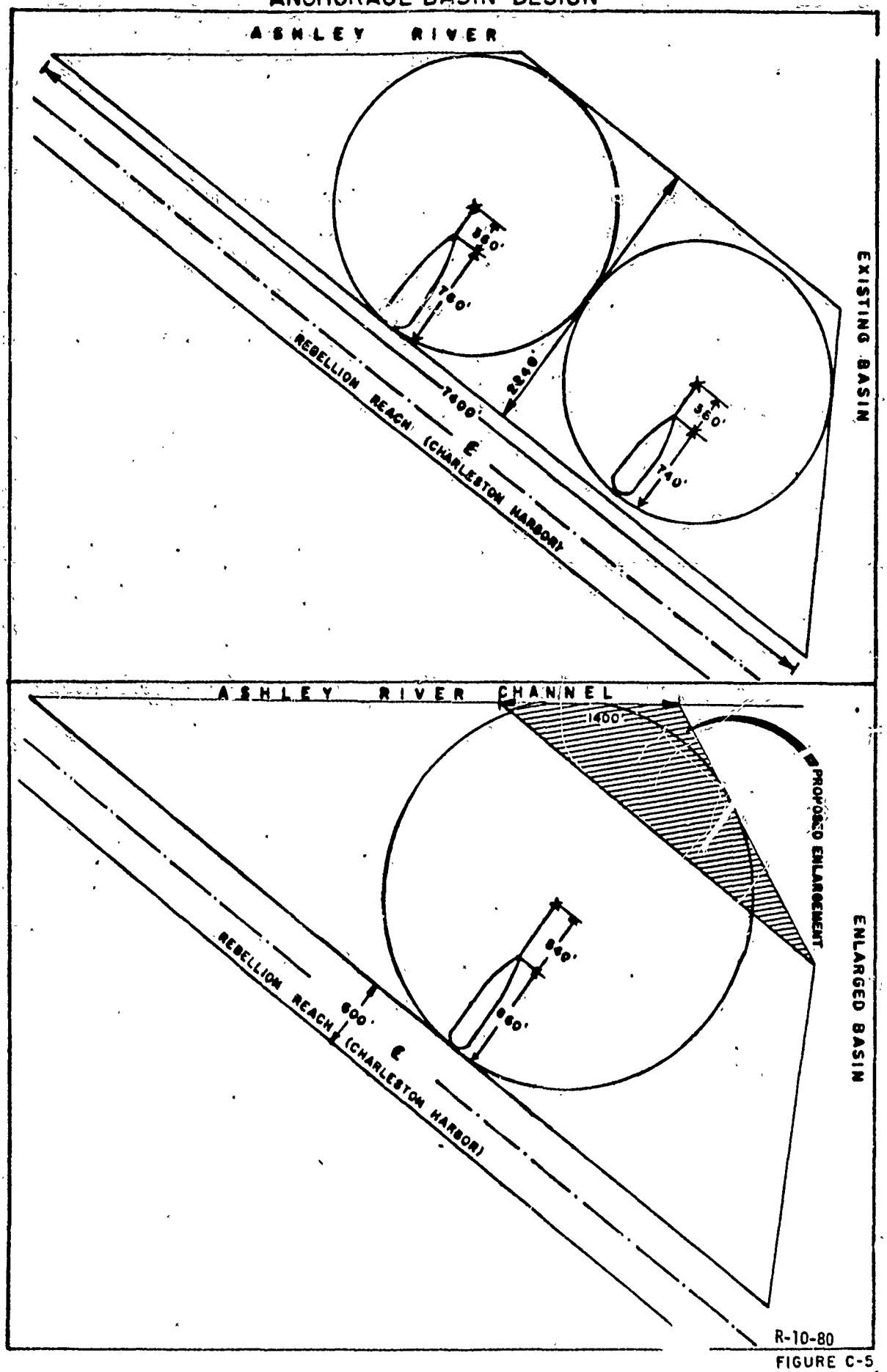
19. Although drilling and sampling operations had been conducted in limited reaches of the harbor for various purposes at different times, a continuous foundation profile of the entrance channel, the harbor, Cooper River and certain other tributaries to the estuary were considered a requirement for completion of the studies enumerated in the project authorization. Most of the previously collected data was found to relate to short reaches of channel alignment, contraction diking, or like undertakings. While limited data was available throughout the harbor and lower Cooper River dating from the year 1878, its usefulness was discounted due to the nature of the earlier sampling equipment and to changes in descriptive terminology. Most of the holes drilled before 1955 were simple wash borings. Therefore, a program of continuous splitspoon

borings and associated sample testing was conducted in 1972 to provide meaningful data on foundation conditions in Charleston Harbor and tributaries. In addition, a Vibrocore drilling program was conducted in 1978 to better define foundation conditions in the entrance channel to Charleston Harbor. In this report, only the data obtained during these two recent drilling programs will be presented in detail, and the earlier data will be referenced in more general terms.

1972 BORING PROGRAM

20. The 41 borings drilled in 1972 in Charleston Harbor are shown in plan on Figure C-6, "Boring Locations, 1972 Drilling Program". These borings were all continuously sampled with a 1-3/8" ID standard penetration splitspoon sampler and the boring logs are shown on Figures C-7 and C-8. A 6-inch flush-joint casing was used to prevent "cave-in" of the borings. The blow count required for each sample using the standard penetration procedure is shown in graphic form beside each plotted boring. In a few selected borings, undisturbed "Denison" samples were taken in layers judged to be Cooper Marl. All borings were referenced to local mean low water (mlw) datum. Generally, each boring was drilled to a depth of 50.0 feet below mean low water. This depth was chosen to provide information relative to possible future deepening of the navigation channel in Charleston Harbor and also to define the surface of the Cooper Marl formation, where encountered. It should be noted that nearly all the borings were taken at the edge of the existing channels to facilitate anchoring of the drill barge, to minimize obstruction to navigation and for purposes of crew safety. This procedure

ANCHORAGE BASIN DESIGN



R-10-80

FIGURE C-5

also ensured that, in most instances, the original undredged surface of the Cooper Marl would be encountered, where this surface lies within the boring depth.

1978 BORING PROGRAM

21. The 26 borings cored on 1 August 1978 in the Charleston Harbor Entrance Channel are shown in plan and profile on Figure C-9. These borings were all continuously sampled with a 3-inch ID plastic core barrel that was vibrated to refusal. Boring logs are also shown on Figure C-9. All borings were referenced to local mean low water (mlw). The depth of each boring varied directly with the resistance of the soils encountered in the channel bottom. In general, a depth of 50 feet below mean low water was targeted since this depth was beyond the proposed project depth. Unlike the splitspooning program of 1972, these samples were extracted along the centerline of the channel. Because of the rapid sampling time (roughly 30 minutes) and control of the vessel, these samples were easily obtained from the center of the channel while causing no obstructions to navigation during this process.

BOTTOM SAMPLES PROGRAM

22. In addition to the above drilling programs, 119 bottom samples were obtained in Charleston Harbor and Cooper River between 24 September and 2 October 1969. These samples were required for the material disposal portion of the authorized Charleston Harbor Navigation Study. The majority of the sampling was done with a "Petterson" dredge sampler

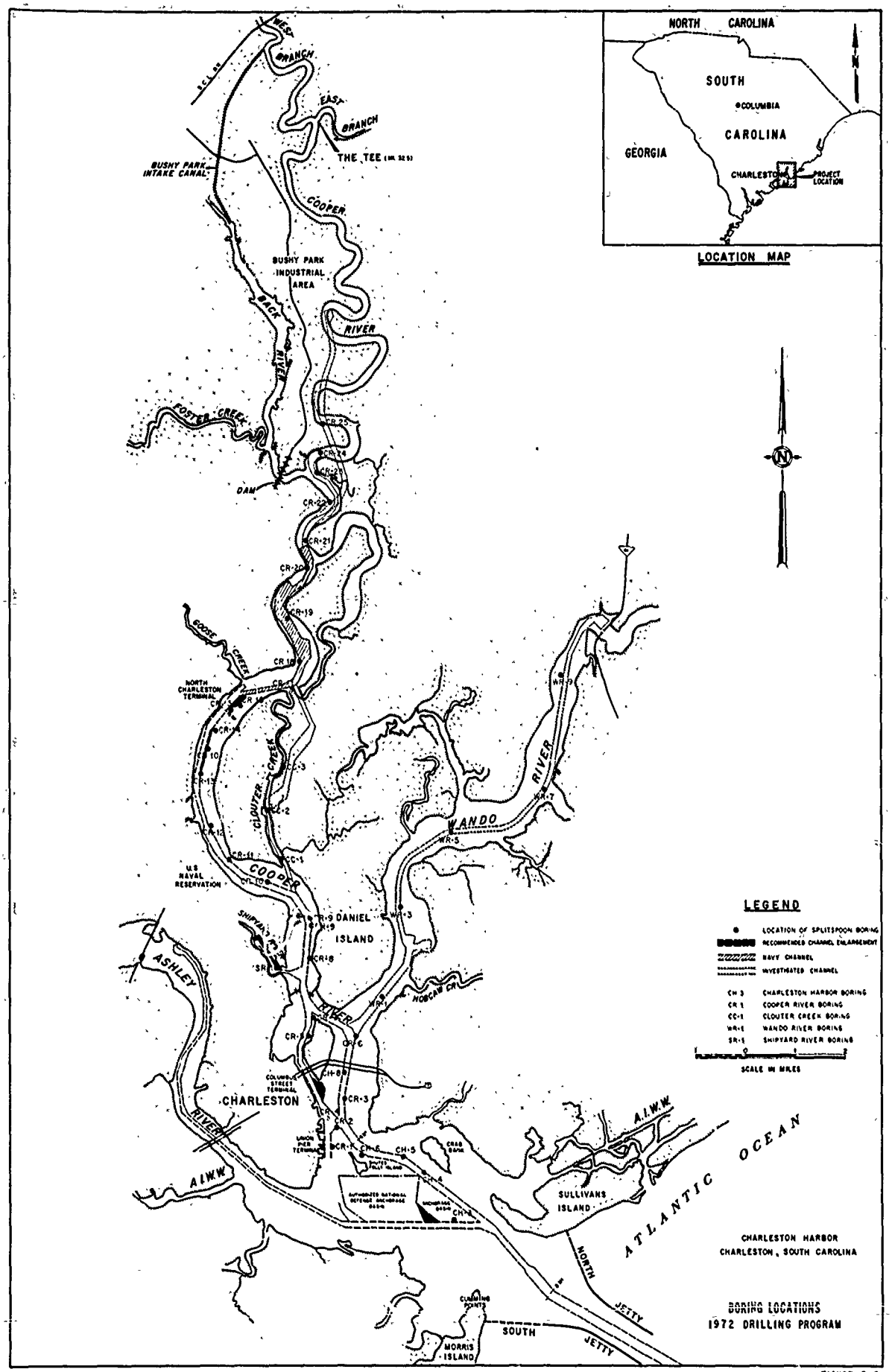
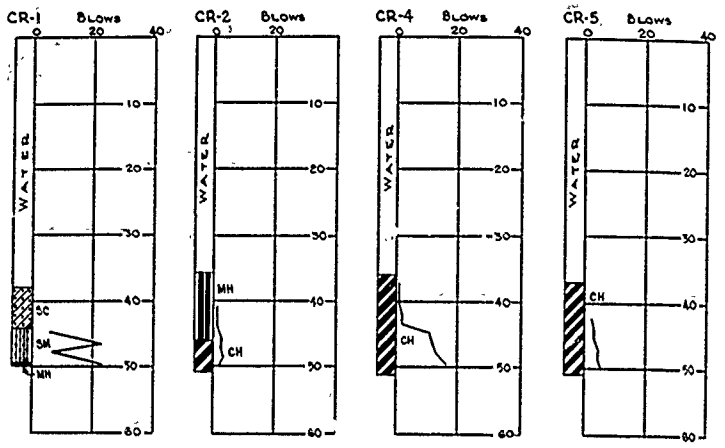

NORTH CAROLINA
SOUTH CAROLINA
COLUMBIA
GEORGIA
CHARLESTON
PROJECT LOCATION
LOCATION MAP
WEST BRANCH
EAST BRANCH
THE TEE
BUSHY PARK INTAKE CANAL
COOPER
BUSHY PARK INDUSTRIAL AREA
BACK RIVER
FOSTER CREEK
DAM
GOOSE CREEK
NORTH CHARLESTON TERMINAL
CLOUTER CREEK
WANDO
RIVER
U.S. NAVAL RESERVATION
DANIEL ISLAND
SHIPYARD CR.
ASHLEY
HORLBECK CR.
CHARLESTON
COLUMBUS STREET TERMINAL
UNION PIER TERMINAL
A.I.W.W.
CRAB BANK
SULLIVANS ISLAND
ATLANTIC OCEAN
NORTH JETTY
SOUTH JETTY
MORRIS ISLAND
CLEANING POINTS
LEGEND
LOCATION OF SPLITSPOON BORING
RECOMMENDED CHANNEL ENLARGEMENT
NAVY CHANNEL
INVESTIGATED CHANNEL
CH-3 CHARLESTON HARBOR BORING
CR-1 COOPER RIVER BORING
CC-1 CLOUTER CREEK BORING
WR-1 WANDO RIVER BORING
SR-1 SHIPYARD RIVER BORING
SCALE IN MILES
CHARLESTON HARBOR
CHARLESTON, SOUTH CAROLINA
BORING LOCATIONS
1972 DRILLING PROGRAM

FIGURE C-6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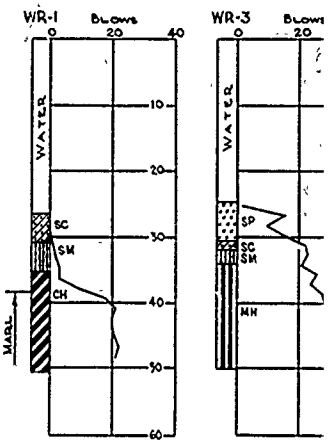
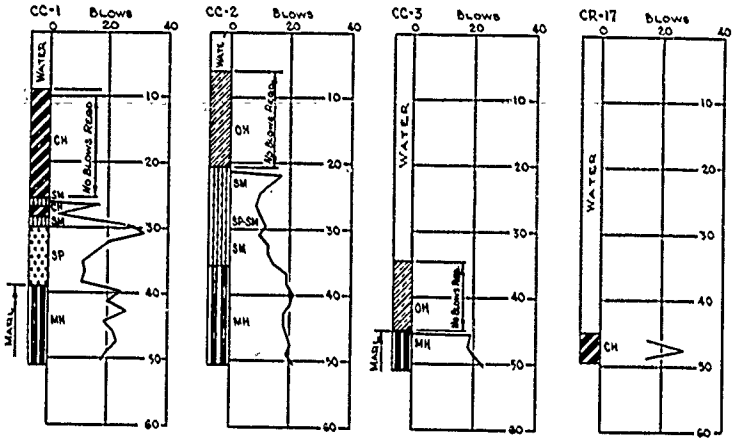
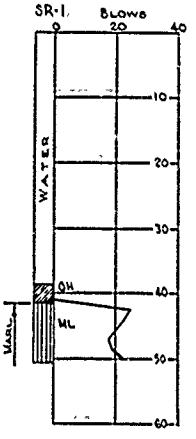
CR-2 Blows
CR-4 Blows
CR-5 Blows
WATER
SC
SM
MH
CH

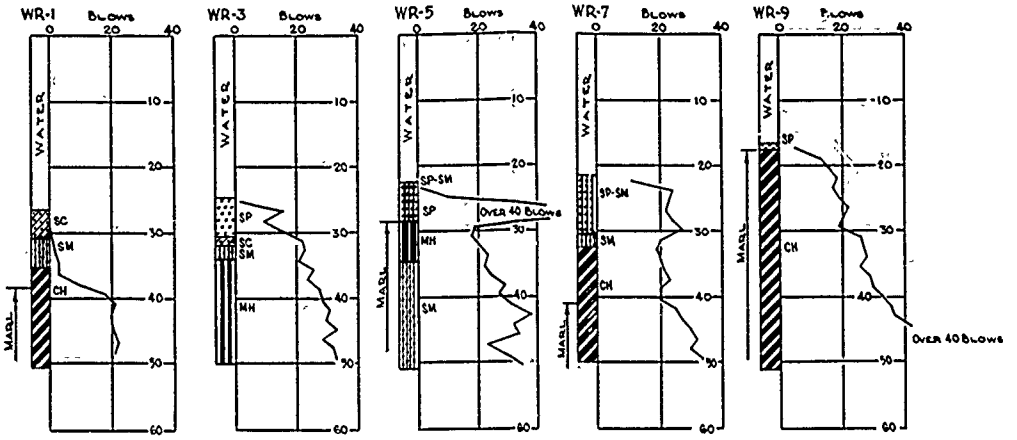

WR-1 Blows
WR-3 Blows
WATER
SC
SM
CH
MARL
SP
MH

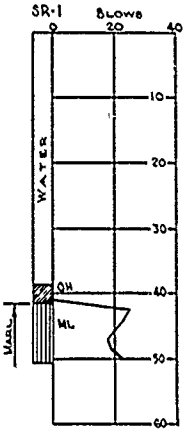

CC-1 Blows
CC-2 Blows
CC-3 Blows
CR-17 Blows
WATER
CH
SM
SP
MH
OH
SP-SM
MARL
No Blows Recd.


SR-1 Blows
WATER
OH
ML
MARL

C-21-a

C-21-B





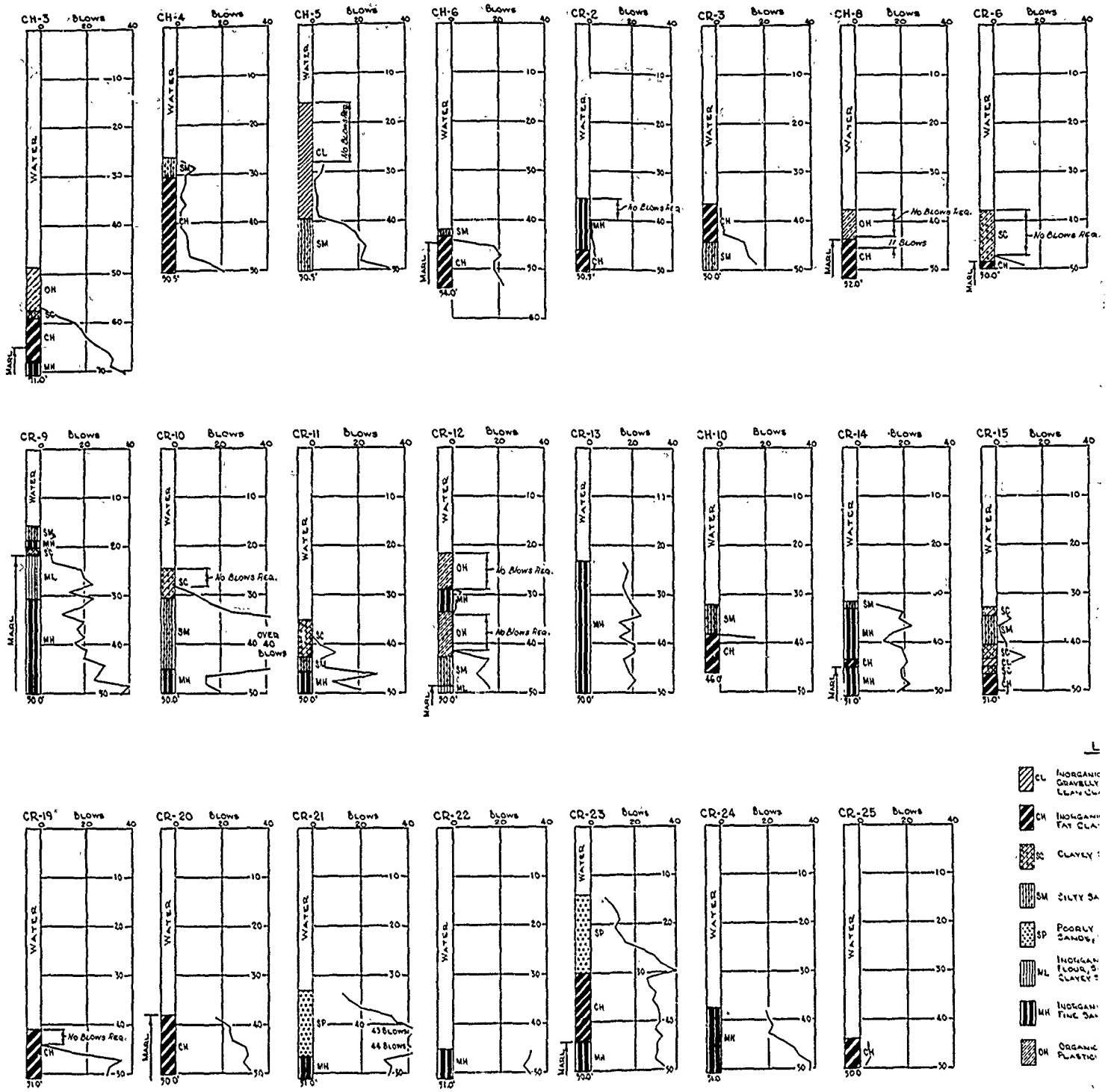
CHARLESTON HARBOR
CHARLESTON, SOUTH CAROLINA
1972 DRILLING PROGRAM

LOGS OF BORINGS

CHARLESTON DISTRICT, CORPS OF ENGINEERS

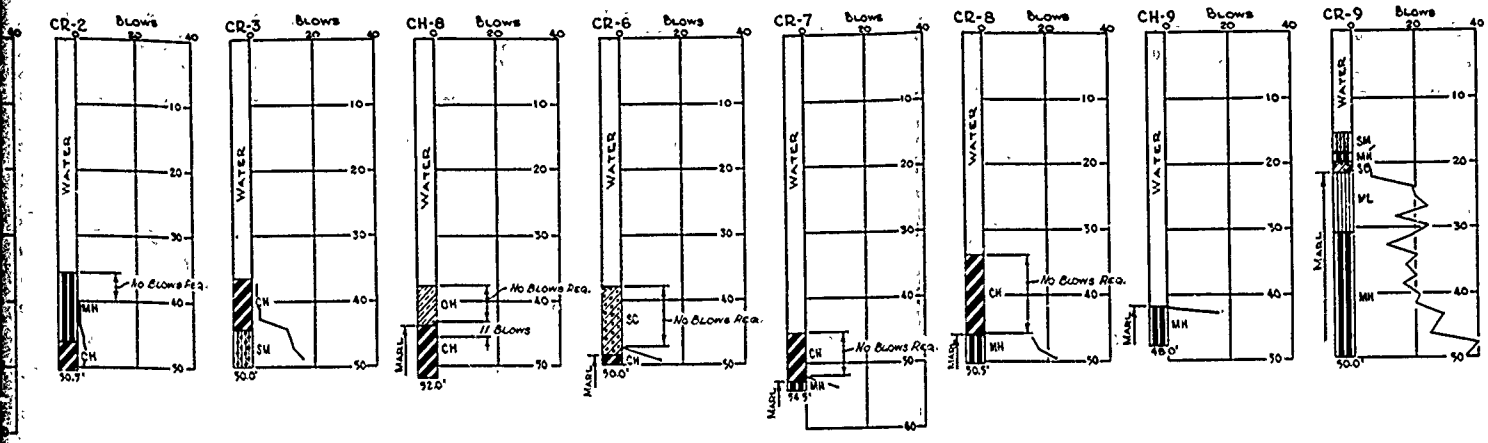
FIGURE C-7

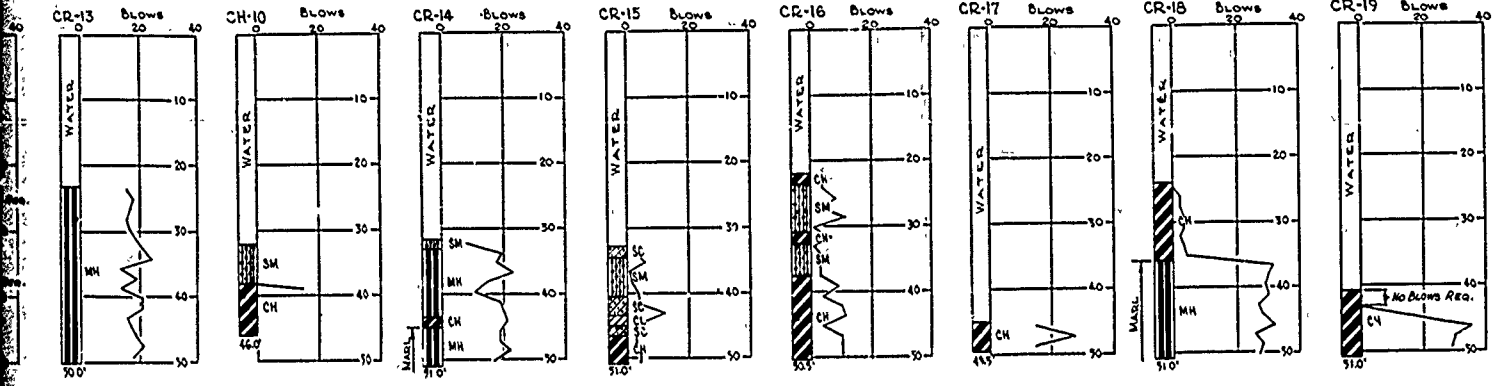
C-21-B

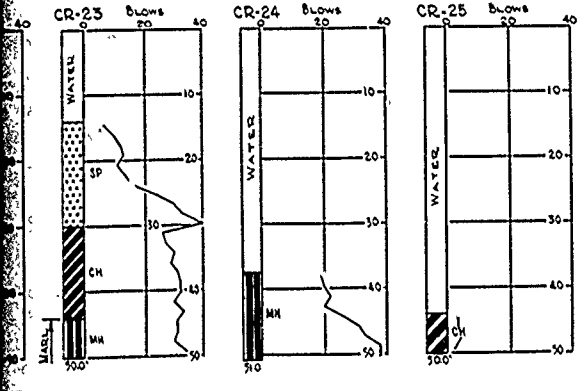

CH-3 Blows
CH-4 Blows
CH-5 Blows
CH-6 Blows
CR-2 Blows
CR-3 Blows
CH-8 Blows
CR-6 Blows
CR-9 Blows
CR-10 Blows
CR-11 Blows
CR-12 Blows
CR-13 Blows
CH-10 Blows
CR-14 Blows
CR-15 Blows
CR-19 Blows
CR-20 Blows
CR-21 Blows
CR-22 Blows
CR-23 Blows
CR-24 Blows
CR-25 Blows
WATER
MARL
No Blows Req.
OVER 40 40 BLOWS
43 BLOWS
44 BLOWS
11 BLOWS
CL
CH
MH
ML
SM
SC
SP
OH
INORGANIC GRAVELLY LEAN CLAY
INORGANIC FAT CLAY
CLAYEY
SILTY SA
POORLY SANDY
INORGANIC FLOUR, S CLAYEY
INORGANIC FINE SA
ORGANIC PLASTIC

C-22-a

C-







LEGEND

- CL — Inorganic Clays Of Low To Medium Plasticity, Gravelly Clays, Sandy Clays, Silty Clays, Lean Clays.
- CH — Inorganic Clays Of High Plasticity, Fat Clays.
- SC — Clayey Sands, Sand-Clay Mixtures.
- SM — Silty Sands, Sand-Silt Mixtures.
- SP — Poorly Graded Sands Or Gravelly Sands, Little Or No Fines.
- ML — Inorganic Silts & Very Fine Sands, Rock Flour, Silty Or Clayey Fine Sands Or Clayey Silts With Slight Plasticity.
- MH — Inorganic Silts, Micaceous Or Diatomaceous Fine Sandy Or Silty Soils, Elastic Silts.
- OH — Organic Clays Of Medium To High Plasticity, Organic Silts.

NOTES:

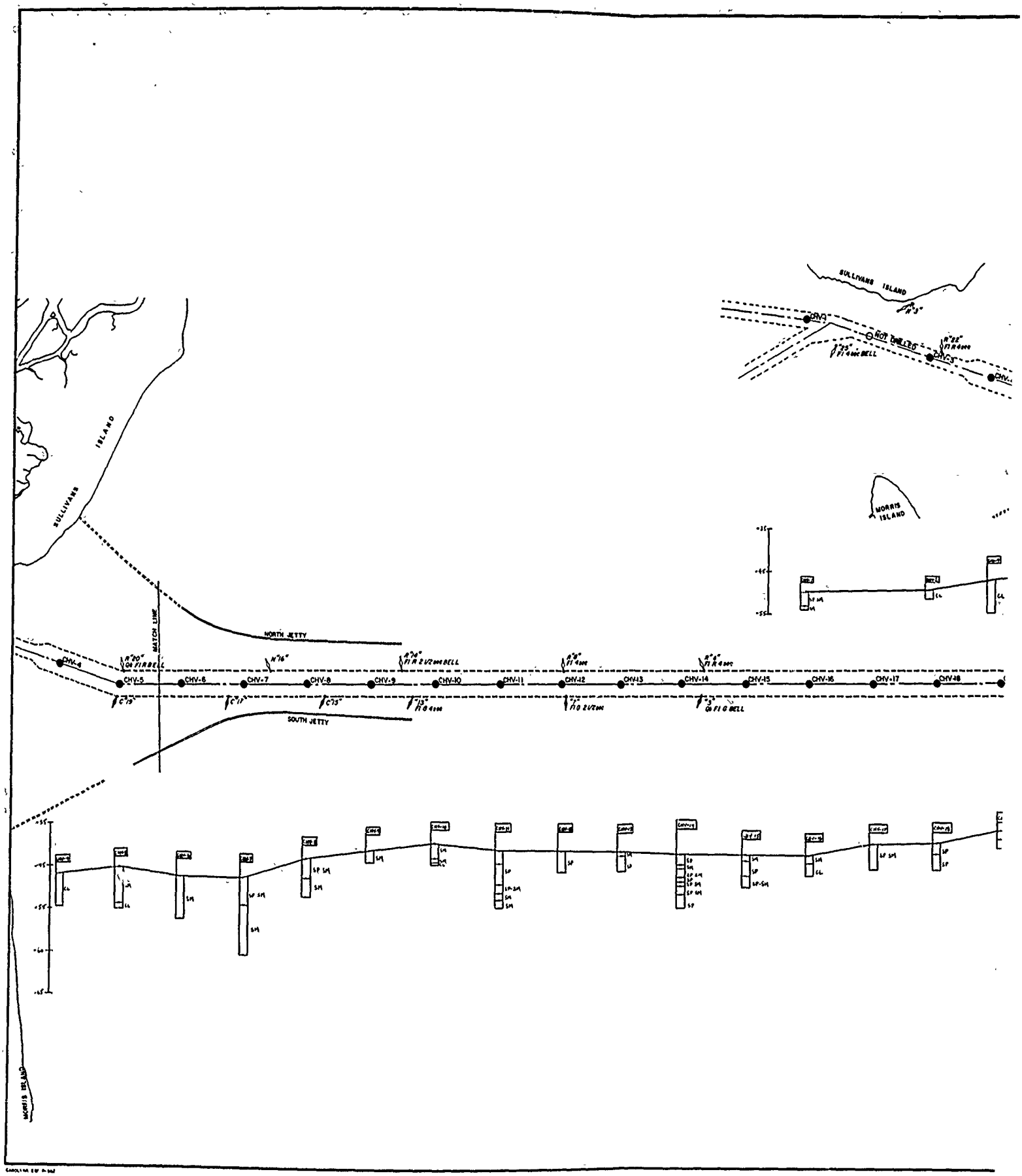
1. Field & Laboratory Soil Classifications Are In Accordance With The Unified Soil Classification System.
2. Depths (Shown Graphically On Each Log) Are In Feet Below Local Mean Low Water Datum.
3. All Borings Are Continuous Splitspoon Borings Advanced According To Standard Penetration Procedure. Blow Count Is Number Of Blows Of 140# Hammer Falling Free A Distance Of 30" Required For One Foot Penetration Of 1 3/8" I.D. Standard Splitspoon Sampler.
4. Where Sampler Advanced Due To Weight Of Drill Rods Only Requiring No Hammer Blows, Each Log Is So Noted.
5. Drilling Was Accomplished Between 16 April & 13 June In 1972.
6. For Location Of Each Boring, See Sheet 1 Of 3 Sheets.

CHARLESTON HARBOR
CHARLESTON, SOUTH CAROLINA
1972 DRILLING PROGRAM
LOGS OF BORINGS

CHARLESTON DISTRICT, CORPS OF ENGINEERS

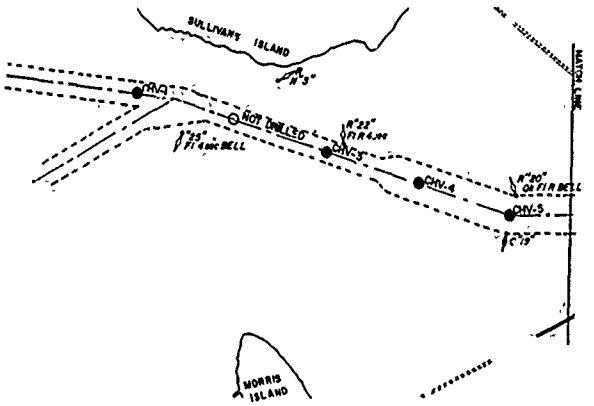
FIGURE C-8

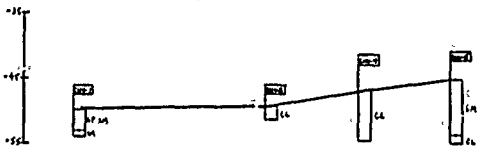
C-22-b

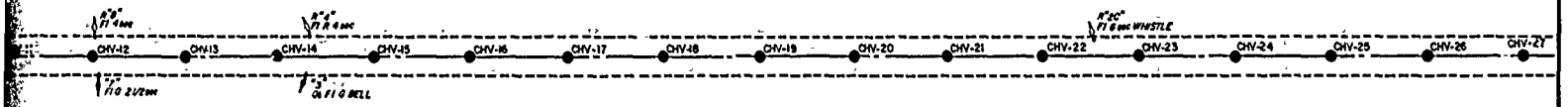

SULLIVANS ISLAND
MORRIS ISLAND
NORTH JETTY
SOUTH JETTY
MATCH LINE
CHV-4
CHV-5
CHV-6
CHV-7
CHV-8
CHV-9
CHV-10
CHV-11
CHV-12
CHV-13
CHV-14
CHV-15
CHV-16
CHV-17
CHV-18

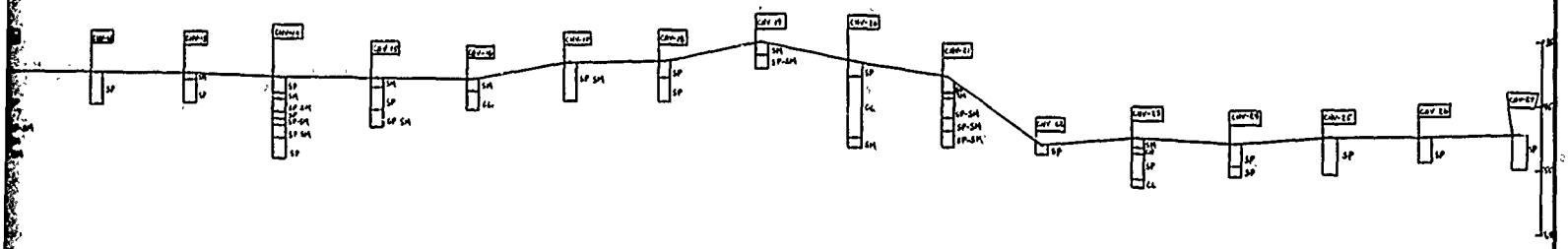
C-23-a

REVISIONS			
SYMBOL	DESCRIPTION	BY	DATE









US ARMY ENGINEER DISTRICT, CHARLESTON CORPS OF ENGINEERS CHARLESTON, SOUTH CAROLINA		
CHARLESTON HARBOR ENTRANCE CHANNEL BORING LOCATIONS 1978 DRILLING PROGRAM		
SCALE 1 20,000	INVITATION NO.:	SHEET OF
DATE:		FILE NO.:

FIGURE C-8

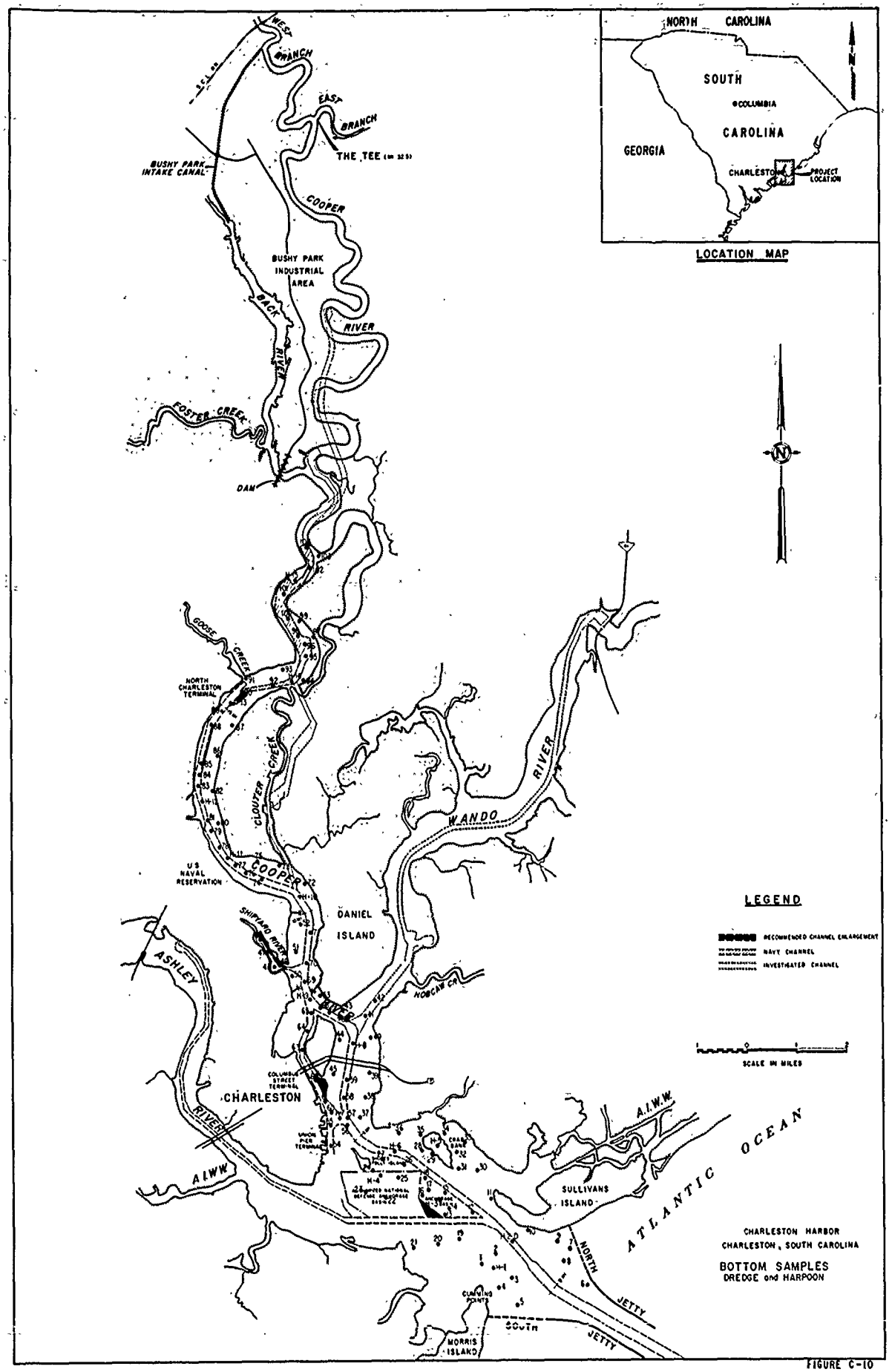

WEST BRANCH
EAST BRANCH
THE TEE
BUSHY PARK INTAKE CANAL
COOPER
BUSHY PARK INDUSTRIAL AREA
BACK RIVER
FOSTER CREEK
DAM
GOOSE CREEK
NORTH CHARLESTON TERMINAL
CLOUTER CREEK
WANDO RIVER
U S NAVAL RESERVATION
COOPER
DANIEL ISLAND
SHIPYARD RIVER
ASHLEY
HOBCAW CR
CHARLESTON
COLUMBUS STREET TERMINAL
RIVER
A.I.W.W.
SULLIVANS ISLAND
ATLANTIC OCEAN
NORTH JETTY
SOUTH JETTY
CLEARING POINT
MORRIS ISLAND
NORTH CAROLINA
SOUTH CAROLINA
COLUMBIA
GEORGIA
CHARLESTON
PROJECT LOCATION
LOCATION MAP
LEGEND
RECOMMENDED CHANNEL ENLARGEMENT
NAVY CHANNEL
INVESTIGATED CHANNEL
SCALE IN MILES
CHARLESTON HARBOR
CHARLESTON, SOUTH CAROLINA
BOTTOM SAMPLES
DREDGE and HARPOON

FIGURE C-10

and the remainder with a "Phleger" core sampler (harpoon type). In use, each of the samplers was suspended by cable from a B-50 sounding reel mounted on a 17-foot survey boat. The location of each sampling point is shown on Figure C-10, "Bottom Samples".

DREDGING SURVEYS

23. A minimum depth of 35 feet below mean low water is authorized for maintenance of the Charleston Harbor Navigation Project. In dredging some reaches of the upper harbor and lower Cooper River channels, the surface of the Cooper Marl formation has been lowered and is overlain by varying depths of soft organic clay (OH) shoal material. In areas where the marl surface was lowered during dredging operations, the surveys made following the dredging of these reaches must be used in addition to the boring results to determine future dredging quantities of marl.

Laboratory Testing

GENERAL

24. On completion of drilling for both the 1972 and the 1978 boring programs, the recovered samples were brought into the District Office for additional inspection. It was considered desirable for personnel of the Foundations and Materials Section to examine the samples in order to gain a closer correlation between the various borings, choose the most representative samples for laboratory testing, and verify the field classification of the soils. Representative samples of the borings were then sent to the South Atlantic Division for testing and classification in accordance with the Unified Soils Classification

System. The remaining samples are stored in the Charleston District Office. The bottom samples were shipped to the South Atlantic Division Laboratory for evaluation. A grain-size mechanical analysis was run on each bottom sample, and the organic content was determined.

TEST DATA

25. Table C-3 is a breakdown by sample number of the general field description of the bottom samples. The breakdown includes the sample number corresponding to the location on Figure C-6, the depth of water at the time of sampling, the firmness of the material encountered, the percent organic content, and the field description of the recovered sample. Table C-4 is a breakdown by sample number of the laboratory gradations of the bottom samples. The laboratory test results for the splitspoon (1972) samples are shown on Tables C-5, C-6 and C-7. Table C-5 lists the borings as they appear in the profiles (Figures C-7 and C-8), the layout of which is based on their location in plan (Figure C-6). Table C-5 includes the boring number, the number of the tested sample, the depth of the sample, the laboratory soil classification symbol, and, where applicable, the natural water content, the Atterburg limits and the mechanical analysis. Tables C-6 and C-7 repeat the Atterburg limits data and the mechanical analysis data, respectively. However, in Tables C-6 and C-7, the tested samples are grouped according to basic soil type. No lab testing was conducted on samples extracted during the 1978 Vibrocore operations.

TABLE C-3

BOTTOM SAMPLES
(DREDGE AND HARPOON)

Sample Number	Depth of Water	Material Firmness	Organic Content (%)	Description (field classification)
		"PETTERSON" DREDGE SAMPLES		
1	8'	Soft	-	Light gray very fine sand.
2	20'	Soft	-	Light gray very fine sand with 1% shell fragments.
3	19'	Hard	-	90% shell and 10% soft sand.
4	14'	Very soft	-	90% light gray mud, 10% very fine shell.
5	21'	Hard	-	99% light gray very fine sand, 1% shell fragments.
6	14'	Hard	-	99% light gray very fine sand, 1% shell fragments.
7	10'	Hard	-	80% light gray very fine sand, 20% shell fragments.
8	17'	Hard	-	60% light gray very fine sand, 40% shell fragments.
9	10'	Med. soft	-	90% light gray very fine sand, 10% shell fragments.
10	11'	Med. soft	-	90% light and dark gray sand, 10% shell fragments.
11	16'	Med. soft	-	95% light gray very fine sand, 5% shell fragments.
12	46'	Hard	-	70% small shell, 30% light gray very fine sand.
13	46'	Very soft	30.3	Dark gray to black silt, axle-grease consistency.
14	41'	Very soft	-	Dark gray to black silt, axle-grease consistency.
15	40'	Very soft	3.2	Dark gray to black silt, axle-grease consistency.
16	34'	Very soft	-	Dark gray to black silt, axle-grease consistency.
17	34'	Very soft	0.5	Dark gray to black silt, axle-grease consistency.
18	37'	Very soft	1.1	Dark gray to black silt, axle-grease consistency.
19	10'	Very soft	0.4	70% light brown to dark gray silt, 30% shell.
20	10'	Hard	-	90% shell, 10% light gray sand.
21	6'	Very soft	-	70% dark gray silt, 30% shell.
22	15'	Med. soft	-	90% light gray very fine sand, 9% silt, 1% shell fragments.
23	15'	Very soft	0.9	80% light gray very fine sand, 19% black silt, 1% shell fragments.
24	12'	Very soft	3.5	Light brown to dark gray silt.
25	24'	Very soft	4.5	95% light brown silt, 5% dark gray silt.
26	11'	Soft	-	90% light gray very fine sand, 10% shell fragments.
27	13'	Soft	-	95% light brown very fine sand, 5% shell fragments.
28	7'	Soft	0.7	60% light gray sand (sticky), 10% light gray silt, 30% shell fragments.
29	5'	Very soft	2.3	80% light gray silt, 20% very fine sand.
30	5'	Hard	-	40% shell, 40% light gray to brown fine sand.
31	5'	Hard	-	99% light gray to brown sand, 1% shell.
32	3'	Soft	0.2	Light gray and brown, 50% very fine sand, 50% silt.
33	10'	Soft	1.1	Dark gray to black, 95% silt (odorous), 5% very fine sand.
34	3'	Soft	6.1	Light gray mud (sticky).
35	0	Soft	1.4	Light brown to dark gray mud (sticky).
36	8'	Med. soft	-	80% light brown mud, 19% very fine sand, 1% shell.
37	-	Med. soft	-	40% shell, 40% light gray very fine sand.
38	-	Hard	0.5	70% shell, 30% light brown sand.
39	-	Soft	2.9	Light brown to black silt or mud (sticky).
40	6'	Very soft	2.0	Light brown to dark gray silt or mud (sticky).
41	30'	Very soft	0.3	Light brown to black silt or mud (sticky).
42	28'	Very soft	2.4	Black silt or mud (sticky).
43	18'	Very soft	-	Light gray silt or mud (sticky).
44	16'	Soft	0.2	Light gray to brown silt or mud (sticky).
45	21'	Very soft	0.2	Light brown to black silt or mud (sticky).
46	40'	Very soft	2.0	Black silt or mud (sticky).
47	42'	Very soft	3.6	Black silt or mud (sticky).
48	-	Very soft	3.3	Black silt or mud (sticky).
49	40'	Very soft	4.8	Black silt or mud (sticky).
50	19'	Very soft	-	Black silt or mud (sticky).
51	20'	Very soft	-	Black silt or mud (sticky).
52	14'	Very soft	1.5	Black silt or mud (sticky).
53	15'	Very soft	-	Black silt or mud (sticky).
54	32'	Soft	1.9	Black silt or mud (sticky).
55	44'	Very soft	-	Dark gray silt or mud (sticky).
56	39'	Very soft	0.2	Dark gray silt or mud (sticky).
57	34'	Hard	-	Dark gray clay (sticky).
58	-	Med. hard	0.5	Dark gray silt or mud (sticky).
59	-	Soft	-	Dark gray silt or mud (sticky).
60	-	Med. hard	-	Dark gray silt or mud (sticky), 20% shell.
61	43'	Very soft	0.5	Dark gray silt or mud (sticky).
62	44'	Very soft	1.2	Dark gray silt or mud (sticky).
63	42'	Very soft	-	Dark gray silt or mud (sticky).
64	42'	Soft	0.4	Dark gray silt or mud (sticky).
65	42'	Soft	-	Dark gray silt or mud (sticky), 10% sand.
66	44'	Very soft	2.6	Black silt or mud (sticky).
67	43'	Hard	-	Dark gray sand, 10% shell fragments.
68	43'	Med. hard	0.9	Dark gray fine sand, 2% shell fragments.
69	44'	Hard	0.3	Shell (all sizes) with lumps of marl.
70	42'	Very soft	2.0	Dark blue black silt or mud (sticky).
71	43'	Very soft	3.3	Dark blue black silt or mud (sticky).
72	16'	Soft	1.7	Dark gray silt or mud (sticky), 20% fine sand.
73	22'	Soft	1.2	Dark gray silt or mud (sticky), 30% fine sand.
74	42'	Soft	3.0	Dark gray silt or mud (sticky), 30% fine sand.
75	14'	Very soft	8.9	Dark gray silt or mud (sticky), no sand.
76	42'	Soft	0.2	Dark gray silt or mud, 30% fine sand, 1% shell.
77	41'	Hard	-	Light to dark gray coarse sand 70%, 30% shell.
78	43'	Very soft	3.8	Dark blue black silt or mud (sticky).
79	42'	Med. soft	2.4	Dark gray thick silt or mud (sticky).
80	23'	Soft	-	Light gray very fine sand.
81	42'	Very soft	1.3	Dark blue black silt or mud (sticky).
82	17'	Hard	0.3	Light gray very coarse sand.
83	41'	Very soft	3.8	Dark blue black silt or mud (sticky).
84	41'	Very soft	6.8	Dark blue black silt or mud (sticky).
85	41'	Very soft	8.3	Dark blue black silt or mud (sticky).
86	15'	Soft	0.2	Light brown very fine sand with trash.
87	24'	Hard	0.5	Light brown coarse sand, 2% shell
88	41'	Very soft	5.4	Dark blue black silt or mud (sticky).
89	41'	Very soft	5.6	Dark brown silt or mud (sticky).
90	39'	Very soft	8.3	Dark blue black silt or mud (sticky).
91	24'	Very soft	3.1	Dark blue black silt or mud (sticky).
92	39'	Med. soft	-	Dark blue black silt or mud (sticky), 30% coarse sand.
93	21'	Very soft	2.0	Dark blue black silt or mud (sticky).
94	20'	Soft	-	Dark gray black thick silt or mud (sticky).
95	39'	Very soft	-	Dark gray black silt or mud (sticky).
96	39'	Very soft	4.9	Dark gray black silt or mud (sticky).
97	19'	Very soft	2.6	Dark gray and blue black silt or mud (sticky).
98	39'	Very soft	8.6	Dark gray and blue black silt or mud (sticky).
99	19'	Very soft	-	Light gray and brown very fine sand.
100	39'	Hard	0.2	Same as #99, but 80% black rock.
101	39'	Soft	0.3	Light gray and blue black very fine sand.
102	39'	Very hard	-	Light brown firm sandy clay.
103	22'	Very soft	3.9	Dark gray and black silt or mud (sticky).
104	39'	Very hard	-	60% black rock, 20% light brown & black sand, 20% shell.
H-20	-	Hard	-	Light brown very fine sand (too hard for harpoon)
		"PHLEGER" CORE SAMPLES (HARPOON)		
H-1	19'	-	-	Light brown fine sand, 1% shell.
H-3	38'	-	2.2	Blue black mud, 30% light gray sand.
H-4	19'	-	-	95% fine sand, 5% dark gray very fine silt.
H-5	0	-	-	Fine sand (lab. class.).
H-6	41'	-	-	Dark gray mud, 10% very fine sand, trace of shell.
H-7	39'	Soft	-	Very fine sand, 2% shell, 1% silt.
H-8	40'	Med. soft	0.4	70% shell fragments, 30% very fine sand.
H-9	43'	-	0.9	Light gray very fine sand.
H-10	42'	-	4.4	Dark gray mud, 10% fine sand.
H-11	43'	-	-	Dark gray mud, 10% fine sand.
H-12	40'	-	5.1	Dark blue black silt or mud.
H-13	39'	-	6.1	Blue black silt or mud.
H-14	39'	-	1.0	Blue black silt or mud.
H-15	27'	Soft	-	Very fine sand.

TABLE C-4

LABORATORY ANALYSIS OF BOTTOM SAMPLES

Sample Number	Organic Content	Percent Passing Sieve* No. 10	No. 40	No. 200	Sample Number	Organic Content	Percent Passing Sieve* No. 10	No. 40	No. 200
				"PETTERSON DREDGE SAMPLES"					
1	-	100	100	7	63	-	100	98	85
2	-	100	100	13	64	0.4%	96	88	49
3	-	82	54	7	65	-	97	93	22
4	-	86	61	8	66	2.6%	100	100	67
5	-	100	99	8	67	-	68	55	7
6	-	100	99	5	68	0.9%	100	98	24
7	-	99	97	4	69	0.3%	52	45	16
8	-	97	83	5	70	2.0%	100	100	77
9	-	100	99	3	71	3.1%	100	99	88
10	-	100	99	3	72	1.7%	100	99	25
11	-	100	99	3	73	1.2%	100	98	37
12	-	82	-	3	74	3.0%	100	78	50
13	30.3%	100	100	80	75	8.9%	100	98	78
14	-	100	98	62	76	0.2%	90	76	23
15	3.2%	100	100	83	77	-	96	19	3
16	-	100	100	46	78	3.8%	100	100	87
17	0.5%	100	100	88	79	2.4%	100	99	93
18	1.1%	100	100	49	80	-	100	64	3
19	0.4%	100	94	46	81	1.3%	100	100	67
20	-	50	36	9	82	0.3%	99	47	4
21	-	100	88	28	83	3.8%	100	98	82
22	-	100	98	22	84	6.8%	100	94	84
23	0.9%	100	98	20	85	8.3%	100	98	89
24	3.5%	100	100	44	86	0.2%	98	71	4
25	4.5%	100	100	72	87	0.5%	99	59	4
26	-	98	96	8	88	5.4%	100	99	75
27	-	100	98	4	89	5.6%	100	100	54
28	0.7%	93	82	24	90	8.3%	100	100	59
29	2.3%	100	99	66	91	3.1%	100	100	68
30	-	87	60	5	92	-	98	81	43
31	-	100	99	5	93	2.0%	100	98	43
32	0.2%	100	98	23	94	-	100	99	95
33	1.1%	100	100	29	95	-	100	100	60
34	6.1%	98	97	48	96	4.9%	100	100	73
35	1.4%	100	99	63	97	2.6%	100	100	82
36	-	99	98	10	98	8.6%	100	100	60
37	-	99	86	16	99	-	100	98	4
38	0.5%	94	72	13	100	0.2%	24	13	1
39	2.9%	100	100	85	101	0.3%	100	100	12
40	2.0%	100	100	38	102	-	100	98	47
41	0.3%	100	92	38	103	3.9%	100	100	66
42	2.4%	100	98	84	104	-	22	17	3
43	-	100	99	80	H-2D	-	98	92	13
44	0.2%	98	97	31					
45	0.2%	100	100	53		"PHLEGER" CORE SAMPLES (HARPOON)			
46	2.0%	100	100	98					
47	3.6%	100	100	98	H-1	-	78	68	19
48	3.3%	100	100	99	H-3	2.2%	100	100	91
49	4.8%	100	100	99	H-4	-	96	90	8
50	-	100	100	80	H-5	-	100	100	3
51	-	100	100	99	H-6	-	98	93	20
52	1.5%	100	99	56	H-7	-	97	93	7
53	-	100	100	44	H-8	0.4%	94	28	5
54	1.9%	100	100	82	H-9	0.9%	100	100	40
55	-	100	100	98	H-10	4.4%	100	100	98
56	0.2%	100	97	42	H-11	-	100	100	99
57	-	100	95	69	H-12	5.1%	100	100	78
58	0.5%	99	99	51	H-13	6.1%	100	100	88
59	-	99	97	42	H-14	1.0%	100	99	69
60	-	98	88	26	H-15	-	73	55	4
61	0.5%	100	100	93					
62	1.2%	100	99	89					

*Percent finer by weight than sieve indicated.

TABLE C-5

LABORATORY TEST RESULTS-CHARLESTON HARBOR

Bor. No:	Samp. No.	Depths: Top	Bot.	Soil Class:	Nat. Wat. Cont.	Atterburg Limits LL:	PL:	PI:	(% Passing) Mechanical Analysis #4	#10	#40	#200
CH-3	1	48.5	50.0	OH	-	105	29	76	-	-	-	-
"	3	59.0	60.5	SC	65.6	-	-	-	100	100	96	27
"	4	60.5	62.0	CH	68.9	50	19	31	100	100	99	84
"	9	68.0	69.5	MH	60.8	147	58	89	100	100	100	90
CH-4	2	28.0	29.5	SM	39.5	-	-	-	100	100	100	19
"	4	31.0	32.5	CH	86.6	114	34	80	100	100	100	98
"	6	34.0	35.5	CH	101.6	113	37	76	100	100	100	86
"	12	43.0	44.5	CH	94.6	125	38	87	100	100	100	99
CH-5	1	16.0	17.5	CL	-	31	20	11	-	-	-	-
"	6	40.0	41.5	SM	28.7	-	-	-	100	100	90	24
"	8	43.0	44.5	SM	23.3	-	-	-	100	100	90	20
CH-6	1	42.0	43.5	SM	31.8	-	-	-	100	100	100	13
"	4	48.0	49.5	CH	65.8	58	22	36	100	100	100	60
CR-2	4*	43.0	44.5	MH	93.1	114	52	62	100	100	99	91
"	8*	49.0	50.5	CH	91.2	89	29	60	100	100	100	83
CR-3	3	39.5	41.0	CH	111.0	112	37	75	100	100	100	97
"	7	45.5	47.0	SM	34.8	43	28	15	100	98	90	29
CH-8	2	44.0	45.5	CH	48.6	76	29	47	100	100	100	78
CR-6	1	38.0	39.5	SC	55.8	45	22	23	100	100	99	48
"	2	48.5	50.0	CH	48.6	75	33	42	100	100	98	82
CR-7	1	45.5	47.0	CH	148.1	147	38	109	100	100	97	87
"	2	53.5	54.5	MH	71.2	148	65	83	100	99	97	81
CR-8	1	34.0	35.5	CH	157.7	114	42	72	100	98	93	74
"	2	46.0	47.5	MH	37.6	53	32	21	100	100	99	71
CH-9	1	42.0	42.5	MH	40.4	54	30	24	100	100	100	74
CR-10	1	24.5	26.0	SC	56.7	70	21	49	100	100	98	38
"	2	29.0	30.5	SC	39.5	41	24	17	100	100	100	40
"	5	33.5	35.0	SM	21.2	-	-	-	100	100	100	16
"	9	39.5	41.0	SP-SM	24.4	-	-	-	100	100	98	6
CR-11	2	39.5	41.0	SC	65.8	50	18	32	100	100	90	30
"	5	44.0	45.5	SM	21.7	-	-	-	100	100	75	21
CR-13	1	23.0	24.5	MH	36.1	50	31	19	100	100	100	70
"	5	29.0	30.5	ML	36.8	48	31	17	100	100	99	68
"	11	38.0	39.5	MH	48.1	75	36	39	100	100	100	66
CH-10	1	32.0	33.5	SM	41.6	32	25	7	100	97	87	22
"	2	38.0	39.5	CH	44.9	77	30	47	100	100	99	72
CR-14	1	31.5	33.0	SP-SM	33.3	-	-	-	99	97	77	8
"	3	34.5	36.0	MH	43.3	62	32	30	100	100	99	75
"	6	39.0	40.5	MH	51.7	68	34	34	100	100	99	70
"	9	43.5	45.0	CH	44.1	72	33	39	100	100	100	68
"	10	45.0	46.5	MH	38.7	67	35	32	100	100	99	60
"	12	48.0	49.5	MH	43.3	60	36	24	100	100	99	58
CR-15	1	33.0	34.5	SC	62.1	60	18	42	100	100	98	42
"	2	34.5	36.0	SM	25.6	-	-	-	100	100	98	13
"	6	40.5	42.0	SC	41.2	30	17	15	100	100	98	28
"	8	43.5	45.0	CL	62.3	49	16	33	100	100	98	60
"	9	45.0	46.5	SC	45.1	32	18	14	100	100	98	43
"	11	48.0	49.5	CH	65.3	83	23	60	100	100	98	65
CR-16	1	22.0	23.5	CH	302.1	155	47	108	100	100	98	87
"	4	26.5	28.0	SM	26.9	-	-	-	100	100	98	17
"	6	29.5	31.0	SP-SM	28.4	-	-	-	94	88	74	11
"	7	31.0	32.5	CH	61.3	65	18	47	100	100	100	70
"	9	34.0	35.5	SM	47.3	-	-	-	100	100	100	41
"	12	38.5	40.0	CH	73.9	97	24	73	100	100	100	86

TABLE C-5 (CONT.)

LABORATORY TEST RESULTS-CHARLESTON HARBOR

Bor. No:	Samp. No:	Depths: Top	Bot.	Soil Class:	Nat. Wat. Cont.	Atterburg Limits LL:	PL:	PI:	(% Passing) Mechanical Analysis #4	#10	#40	#200
CR-17	3*	48.0	49.5	CH	46.6	63	29	34	100	100	99	73
CR-18	1	24.0	25.5	CH	286.1	171	45	126	100	100	100	95
"	3	28.5	30.0	CH	75.4	89	24	65	100	100	97	63
"	5	34.5	36.0	CH	83.5	81	26	55	100	100	99	83
"	7	39.0	40.5	MH	39.7	56	34	22	100	100	98	51
"	10	48.0	49.5	MH	49.3	76	37	39	100	100	100	70
CR-19	1	41.0	42.5	CH	118.8	100	30	70	100	100	99	83
"	2	44.0	45.5	CH	48.1	72	29	43	100	100	100	77
"	4	47.0	48.5	CH	49.3	72	29	43	100	100	100	76
CR-20	2	41.0	42.5	CH	49.0	73	30	43	100	100	100	77
"	5	48.5	50.0	CH	49.3	71	28	43	100	100	100	76
CR-21	1	33.0	34.5	SP	18.8	-	-	-	100	96	32	2
"	5	42.0	43.5	SP	20.5	-	-	-	100	96	31	0
"	7	46.5	48.0	MH	43.9	53	36	17	100	100	98	52
CR-22	1	45.0	46.5	MH	32.5	52	34	18	100	100	99	52
CR-23	1	14.0	15.5	SP	26.7	-	-	-	100	99	90	2
"	5	26.0	27.5	SP	26.0	-	-	-	100	99	95	4
"	7	30.0	30.5	CH	64.7	82	30	52	100	100	98	86
"	12	44.0	45.5	MH	-	70	34	36	-	-	-	-
CR-24	1	37.5	39.0	MH	41.2	62	34	28	100	100	99	69
"	3	43.5	45.0	MH	41.2	62	34	28	100	100	99	68
CR-25	1	44.0	45.5	CH	107.0	104	29	75	100	100	98	93
CR-1	1	38.0	39.5	SC	85.9	78	25	53	100	100	98	48
"	2	44.0	45.5	SP-SM	32.8	-	-	-	93	87	72	12
CR-2	4*	43.0	44.5	MH	93.1	114	52	62	100	100	99	91
"	8*	49.0	50.5	CH	91.2	89	29	60	100	100	100	83
CR-4	1	36.0	37.5	CH	180.9	140	42	98	100	100	100	87
"	2	37.5	39.0	CH	111.0	117	38	79	100	100	99	97
"	6	43.5	45.0	CH	116.5	130	38	92	100	100	100	98
CR-5	1	37.0	38.5	CH	107.9	101	33	68	100	100	99	94
"	5	43.0	44.5	CH	105.3	117	45	72	100	100	100	92
"	9	49.5	51.0	CH	97.2	123	37	86	100	100	99	93
WR-1	1	26.5	28.0	SC	38.1	36	17	19	100	99	83	22
"	3	32.5	34.0	SM	31.8	-	-	-	100	99	83	16
"	5	35.5	37.0	CH	45.1	54	20	34	100	100	96	51
"	6	37.0	38.5	CH	77.7	86	27	59	100	100	99	87
"	8	41.5	43.0	CH	45.3	71	31	40	100	100	98	68
WR-3	2	26.0	27.5	SP	19.8	-	-	-	100	99	32	3
"	6	32.0	33.5	SM	24.1	36	30	6	94	90	85	33
"	9	39.5	41.0	MH	52.2	78	42	36	100	100	99	74
WR-5	1	22.5	24.0	SP-SM	24.8	-	-	-	100	98	70	8
"	3	25.5	27.0	SP	17.6	-	-	-	82	80	37	4
"	5	28.5	30.0	MH	46.4	76	39	37	100	100	99	78
"	7	34.5	36.0	SM	31.8	44	27	17	100	100	97	38
"	8	39.0	40.5	SM	24.1	-	-	-	100	100	95	14
"	9	43.5	45.0	SM	23.9	-	-	-	100	100	95	15
WR-7	4	26.0	27.5	SP-SM	22.2	-	-	-	100	100	87	6
"	7	30.5	32.0	SM	17.8	-	-	-	79	72	56	17
"	10	39.5	41.0	CH	44.3	77	31	46	100	100	98	77
"	11	42.5	44.0	CH	59.0	102	25	77	100	100	100	94
WR-9	1	16.5	17.5	SP	24.2	-	-	-	100	93	52	4
"	3	21.0	22.5	CH	65.6	110	38	72	100	100	100	86
"	9	46.5	48.0	CH	31.8	54	27	27	100	100	98	57

TABLE C-5 (CONT.)

LABORATORY TEST RESULTS-CHARLESTON HARBOR

Bor. No:	Samp. No:	Depths: Top	Bot.	Soil Class:	Nat. Wat. Cont.	Atterburg Limits LL:	PL:	PI:	(% Passing) Mechanical Analysis #4	#10	#40	#200
CC-1	1	9.0	10.5	CH	259.7	160	43	117	100	100	97	89
"	3	18.0	19.5	CH	286.1	164	40	124	100	100	98	90
"	5	22.5	24.0	CH	111.0	127	33	94	100	100	100	96
"	7	25.5	27.0	SM	29.9	-	-	-	100	100	98	15
"	8	27.0	28.5	CH	89.0	115	32	83	100	100	99	85
"	9	28.5	30.0	SM	16.6	-	-	-	100	100	90	21
"	11	31.5	33.0	SP	25.0	-	-	-	100	100	97	3
"	17	40.5	42.0	MH	75.4	157	65	92	100	100	100	92
CC-2	2	20.5	22.0	SM	21.8	-	-	-	100	100	88	14
"	5	25.0	26.0	SP-SM	27.4	-	-	-	100	100	98	5
"	10	32.5	34.0	SP-SM	23.3	-	-	-	100	100	97	7
"	12	35.5	37.0	MH	36.1	54	33	21	100	100	100	69
CC-3	1	34.5	36.0	OH	192.0	198	51	147	100	100	98	91
"	2	45.0	46.5	MH	59.0	97	44	53	100	100	100	78
CR-17	3*	48.0	49.5	CH	46.6	63	29	34	100	100	99	73
SR-1	2	41.5	43.0	ML	32.5	46	29	17	100	100	99	70

*Boring Nos. CR-2 & CR-17 appear in more than one profile grouping and are listed here accordingly.

Notes: Borings listed in this table (Table F-3) according to their location on the boring log sheets (Figures 2 & 3). Atterburg limits grouped according to soil classification on Table F-4. Mechanical analyses grouped according to soil classification on Table F-5. Unified soil classification system used on all samples. Testing accomplished at South Atlantic Division Laboratory. Test reports available at Charleston District Engineer Office.

TABLE C-6

ATTERBURG LIMITS-CHARLESTON HARBOR

	Material Classification:	Bor. No:	Samp. No:	Atterburg Limits: LL:	PL:	PI:
	Silty Sand (SM)	CR-3	7	43	28	15
	" " "	CH-10	1	32	25	7
	" " "	WR-3	6	36	30	6
	" " "	WR-5	7	44	27	17
	Clayey Sand (SC)	CR-6	1	45	22	23
	" " "	CR-10	1	70	21	49
	" " "	"	2	41	24	17
	" " "	CR-11	2	50	18	32
	" " "	CR-15	1	60	18	42
	" " "	"	6	30	17	15
	" " "	"	9	32	18	14
	" " "	CR-1	1	78	25	53
	" " "	WR-1	1	36	17	19
	Silt (ML)-Low Plas.	CR-13	5	48	31	17
	" " " "	SR-1	2	46	29	17
	Clay (CL)-Low Plas.	CH-5	1	31	20	11
	" " " "	CR-15	8	49	16	33
	Silt (MH)-High Plas.	CH-3	9	147	58	89
*	" " " "	CR-2	4	114	52	62
	" " " "	CR-7	2	148	65	83
	" " " "	CR-8	2	53	32	21
	" " " "	CH-9	1	54	30	24
	" " " "	CR-13	1	50	31	19
	" " " "	"	11	75	36	39
	" " " "	CR-14	3	62	32	30
	" " " "	"	6	68	34	34
	" " " "	"	10	67	35	32
	" " " "	"	12	60	36	24
	" " " "	CR-18	7	56	34	22
	" " " "	"	10	76	37	39
	" " " "	CR-21	7	53	36	17
	" " " "	CR-22	1	52	34	18
	" " " "	CR-23	12	70	34	36
	" " " "	CR-24	1	62	34	28
	" " " "	"	3	62	34	28
	" " " "	WR-3	9	78	42	36
	" " " "	WR-5	5	76	39	37
	" " " "	CC-1	17	157	65	92
	" " " "	CC-2	12	54	33	21
	" " " "	CC-3	2	97	44	53
	Clay (CH)-High Plas.	CH-3	4	50	19	31
	" " " "	CH-4	4	114	34	80
	" " " "	"	6	113	37	76
	" " " "	"	12	125	38	87
	" " " "	CH-6	4	58	22	36
*	" " " "	CR-2	8	89	29	60
	" " " "	CR-3	3	112	37	75
	" " " "	CH-8	2	76	29	47
	" " " "	CR-6	2	75	33	42

TABLE C-6 (CONT.)

ATTERBURG LIMITS-CHARLESTON HARBOR

Material Classification:	Bor. No:	Samp. No:	Atterburg Limits: LL:	PL:	PI:
Clay (CH)-High Plas.	CR-7	1	147	38	109
" " " "	CR-8	1	114	42	72
" " " "	CH-10	2	77	30	47
" " " "	CR-14	9	72	33	39
" " " "	CR-15	11	83	23	60
" " " "	CR-16	1	155	47	108
" " " "	"	7	65	18	47
" " " "	"	12	97	24	73
" " " "	CR-17	3	63	29	34
" " " "	CR-18	1	171	45	126
" " " "	"	3	89	24	65
" " " "	"	5	81	26	55
" " " "	CR-19	1	100	30	70
" " " "	"	2	72	29	43
" " " "	"	4	72	29	43
" " " "	CR-20	2	73	30	43
" " " "	"	5	71	28	43
" " " "	CR-23	7	82	30	52
" " " "	CR-25	1	104	29	75
" " " "	CR-4	1	140	42	98
" " " "	"	2	117	38	79
" " " "	"	6	130	38	92
" " " "	CR-5	1	101	33	68
" " " "	"	5	117	45	72
" " " "	"	9	123	37	86
" " " "	WR-1	5	54	20	34
" " " "	"	6	86	27	59
" " " "	"	8	71	31	40
" " " "	WR-7	10	77	31	46
" " " "	"	11	102	25	77
" " " "	WR-9	3	110	38	72
" " " "	"	9	54	27	27
" " " "	CC-1	1	160	43	117
" " " "	"	3	164	40	124
" " " "	"	5	127	33	94
" " " "	"	8	115	32	83
Organic Clay (OH)	CH-3	1	105	29	76
" " "	CC-3	1	198	51	147

TABLE C-7

MECHANICAL ANALYSES-CHARLESTON HARBOR

Material Classification:	Bor. No:	Samp. No:	Mechanical Analysis (Percent Passing) #4	#10	#40	#200
Sand (SP) Poorly Graded	CR-21	1	100	96	32	2
" " " "	"	5	100	96	31	0
" " " "	CR-23	1	100	99	90	2
" " " "	"	5	100	99	95	4
" " " "	WR-3	2	100	99	32	3
" " " "	WR-5	3	82	80	37	4
" " " "	WR-9	1	100	93	52	4
" " " "	CC-1	11	100	100	97	3
Silty Sand (SP-SM) Poor Grad.	CR-10	9	100	100	98	6
" " " " " "	CR-14	1	99	97	77	8
" " " " " "	CR-16	6	94	88	74	11
" " " " " "	CR-1	2	93	87	72	12
" " " " " "	WR-5	1	100	98	70	8
" " " " " "	WR-7	4	100	100	87	6
" " " " " "	CC-2	5	100	100	98	5
" " " " " "	"	10	100	100	97	7
Silty Sand (SM)	CH-4	2	100	100	100	19
" " "	CH-5	6	100	100	90	24
" " "	"	8	100	100	90	20
" " "	CH-6	1	100	100	100	13
" " "	CR-3	7	100	98	90	29
" " "	CR-10	5	100	100	100	16
" " "	CR-11	5	100	100	75	21
" " "	CH-10	1	100	97	87	22
" " "	CR-15	2	100	100	98	13
" " "	CR-16	4	100	100	98	17
" " "	"	9	100	100	100	41
" " "	WR-1	3	100	99	83	16
" " "	WR-3	6	94	90	85	33
" " "	WR-5	7	100	100	97	38
" " "	"	8	100	100	95	14
" " "	"	9	100	100	95	15
" " "	WR-7	7	79	72	56	17
" " "	CC-1	7	100	100	98	15
" " "	"	9	100	100	90	21
" " "	CC-2	2	100	100	88	14
Clayey Sand (SC)	CH-3	3	100	100	96	27
" " "	CR-6	1	100	100	99	48
" " "	CR-10	1	100	100	98	38
" " "	"	2	100	100	100	40
" " "	CR-11	2	100	100	90	30
" " "	CR-15	1	100	100	98	42
" " "	"	6	100	100	98	28
" " "	"	9	100	100	98	43
" " "	CR-1	1	100	100	98	48
" " "	WR-1	1	100	99	83	22
Silt (ML) - Low Plas.	CR-13	5	100	100	99	68
" " " "	SR-1	2	100	100	99	70
Clay (CL) - Low Plas.	CR-15	8	100	100	98	60

TABLE C-7 (CONT.)

MECHANICAL ANALYSES-CHARLESTON HARBOR

	Material Classification:	Bor. No:	Samp. No:	Mechanical Analysis (Percent Passing) #4	#10	#40	#200
	Silt (MH) - High Plas.	CH-3	9	100	100	100	90
*	" " " "	CR-2	4	100	100	99	91
	" " " "	CR-7	2	100	99	97	81
	" " " "	CR-8	2	100	100	99	71
	" " " "	CH-9	1	100	100	100	74
	" " " "	CR-13	1	100	100	100	70
	" " " "	"	11	100	100	100	66
	" " " "	CR-14	3	100	100	99	75
	" " " "	"	6	100	100	99	70
	" " " "	"	10	100	100	99	60
	" " " "	"	12	100	100	99	59
	" " " "	CR-18	7	100	100	99	51
	" " " "	"	10	100	100	100	70
	" " " "	CR-21	7	100	100	98	52
	" " " "	CR-22	1	100	100	99	52
	" " " "	CR-24	1	100	100	99	60
	" " " "	"	3	100	100	99	69
	" " " "	WR-3	9	100	100	99	74
	" " " "	WR-5	5	100	100	99	78
	" " " "	CC-1	17	100	100	100	92
	" " " "	CC-2	12	100	100	100	69
	" " " "	CC-3	2	100	100	100	78
	Clay (CH) - High Plas.	CH-3	4	100	100	99	84
	" " " "	CH-4	4	100	100	100	89
	" " " "	"	6	100	100	100	86
	" " " "	"	12	100	100	100	99
	" " " "	CH-6	4	100	100	100	60
*	" " " "	CR-2	8	100	100	100	93
	" " " "	CR-3	3	100	100	100	97
	" " " "	CH-8	2	100	100	100	78
	" " " "	CR-6	2	100	100	98	82
	" " " "	CR-7	1	100	100	97	87
	" " " "	CR-8	1	100	98	93	74
	" " " "	CH-10	2	100	100	99	72
	" " " "	CR-14	9	100	100	100	69
	" " " "	CR-15	11	100	100	98	65
	" " " "	CR-16	1	100	100	98	87
	" " " "	"	7	100	100	100	70
	" " " "	"	12	100	100	100	86
*	" " " "	CR-17	3	100	100	99	73
	" " " "	CR-18	1	100	100	100	95
	" " " "	"	3	100	100	97	63
	" " " "	"	5	100	100	99	83
	" " " "	CR-19	1	100	100	99	83
	" " " "	"	2	100	100	100	77
	" " " "	"	4	100	100	100	76
	" " " "	CR-20	2	100	100	100	77
	" " " "	"	5	100	100	100	76
	" " " "	CR-23	7	100	100	98	86
	" " " "	CR-25	1	100	100	98	93
	" " " "	CR-4	1	100	100	100	87
	" " " "	"	2	100	100	99	97
	" " " "	"	6	100	100	100	98
	" " " "	CR-5	1	100	100	99	94
	" " " "	"	5	100	100	100	92
	" " " "	"	9	100	100	99	93
	" " " "	WR-1	5	100	100	96	51
	" " " "	"	6	100	100	99	87
	" " " "	"	8	100	100	98	68
	" " " "	WR-7	10	100	100	98	77
	" " " "	"	11	100	100	100	94
	" " " "	WR-9	3	100	100	100	86

TABLE C-7 (CONT.)

MECHANICAL ANALYSES-CHARLESTON HARBOR

Material Classification:	Bor No:	Samp. No:	Mechanical Analysis (Percent Passing) #4	#10	#40	#200
Clay (CH) - High Plas.	WR-9	9	100	100	98	57
" " " "	CC-1	1	100	100	97	89
" " " "	"	3	100	100	98	90
" " " "	"	5	100	100	100	96
" " " "	"	8	100	100	99	85
Organic Clay (OH)	CC-3	1	100	100	98	91

FUTURE TESTING

26. The "Denison" tube samples of Cooper Marl referred to earlier in this report were obtained for possible future testing. This was done in order to preclude an additional mobilization of the drill barge and equipment should further evaluation of the marl characteristics be required. Three (3) "Denison" tube cores are stored in the humid room of the South Atlantic Division Laboratory and five others are being held in the District Office. No testing of the cores has been planned or accomplished to date.

Engineering Considerations

STRATIGRAPHY

27. 1972 Drilling Program (Inner Harbor and Tributaries). The location of each boring near the edge of the navigation channel resulted in considerable variation in depth to river bed from one boring to the next, since the procedure placed most of the borings on or near the cut-slope of the channel cross-section. The borings indicate a wide variance in depths and continuity of layers of material above the Cooper Marl formation. The marl surface elevation varies as much as 50 feet between borings due to the existence of ancient channels and the generally irregular marl surface. A "typical" boring would probably show from five to eight feet of very soft organic or inorganic silt or clay material at the top of the hole. Beneath this material would be firmer layers of silty or clayey sand, 5 feet to 10 feet in total thickness. Beneath the sandy material mentioned, a dense layer of fat clay or silt would appear atop the Cooper Marl. While this "typical" boring is nebulous from a soils classification standpoint due to the wide variation in encountered materials between borings, it is meaningful from the standpoint of material strength which is of great concern in this report. In some areas, there is an absence of the very soft material normally encountered at the top of the borings, and this is probably due to localized scour by the stronger tidal currents. Investigations consistently indicate that the Cooper Marl is the hardest to dredge of the materials in Charleston Harbor and Cooper River.

1978 DRILLING PROGRAM

28. 1978 Drilling Program (Charleston Harbor Entrance Channel). Each boring was taken along the centerline of the entrance channel (leading into Charleston Harbor). The borings indicate bottom elevations ranging from -35 feet mlw to -55 feet mlw with a wide variance in continuity of layers of material lying above the Cooper Marl formation. A "typical" boring in the entrance channel would probably show from three to five feet of poorly graded sand containing a large amount of shell fragments. Beneath this layer and just above the marl would be three to five feet of fine-grained silt to a sandy clay. In some borings a cemented poorly graded sand was encountered that was determined to be discontinuous, although several feet thick. The investigations indicate that the poorly graded cemented sand and the Cooper Marl would be the most difficult materials to dredge in the entrance channel.

MATERIAL CHARACTERISTICS

29. The dense subsurface material found in Charleston Harbor and entrance channel and termed "Cooper Marl" is calcareous and tends to be greenish in color. The Cooper Marl formation is massive, and once encountered will extend to the total depth of any presently conceived prospective dredging operation. Using the Unified Soil Classification System, the marl will usually fall into the highly plastic clay or silt category (CH or MH); but occasionally the marl will classify as a silt of low plasticity or a silty sand (ML or SM). The CH and MH marls have a greater quantity of sand sizes than is normally expected with high liquid limit material. In four samples with liquid limits above 147, the sand content ranged from 8 to 18 percent. This accounts in part for the difficulty experienced during dredging operations as well as for the good strength characteristics exhibited by the Cooper Marl. Marls in the lower liquid

limit range frequently contain 25 to 30 percent sand by weight. A minimum of 20 to 30 blows of standard penetration equipment is normally required in Cooper Marl, and the material tends to become harder to penetrate as the depth into the formation increases. Although some geologists recognize more recent marl formations as overlying the Cooper Marl in some areas of Charleston Harbor, this controversy is ignored in the reporting on the subsurface investigation as it regards the boring program, since the only differences significant to soils engineering are reflected in the boring logs (classification, blow count, etc.).

AVAILABILITY OF DRILLING LOGS AND LABORATORY DATA

30. Drilling logs and laboratory data sheets for each boring are available for public use in the District Office.

Subsurface Conclusions

31. Based on subsurface information obtained to date, all materials known to exist in Entrance Channel, Charleston Harbor, and Cooper River and certain other tributaries to the estuary are considered dredgeable with a cutterhead pipeline dredge; and data available from previous dredging operations along with the latest boring information will be sufficient for the preparation of estimates of first cost for various channel improvements. A special cutterhead may be required in order to dredge the cemented sand from the entrance channel. However, because of the small comparative quantity of this material involved, the cost of dredging is not expected to be significantly affected by it.

Estimates of First Costs and Annual Equivalent Charges

PLANS OF IMPROVEMENT

32. Based on the above considerations, the estimated first cost and average annual equivalent charge was determined for three plans of improvement essentially varying only in project depth. The plans of improvement considered improved project depths of 38, 40 and 42 feet, respectively. In addition to deepening the existing waterway, each plan included the following items of commensurate depth with the project depth being considered: (a) construction of a new turning basin adjacent to the Columbus Street docks, (b) enlargement of the existing turning basin at the head of commercial navigation (Goose Creek), (c) enlargement of the National Defense Anchorage, (d) realignment of the channel centerline to provide 125 feet between existing docks, piers, etc., and the edge of the channel, and (e) other easing of bends and minor channel alignment changes to mitigate difficulties attending navigation. The waterway was divided into two sections in order that the modifications to Shipyard River and Charleston Harbor could be individually evaluated.

33. The estimated Federal and non-Federal first costs, total project first cost, and annual charges for each modified depth considered are shown in Table C-8. These estimates are based on the use of upland disposal.

VOLUME COMPUTATIONS

34. In order to facilitate volume computations, base maps were prepared using contract dredging drawings where possible to provide coverage from the entrance channel to the head of navigation. These

TABLE C-8

SUMMARY OF ESTIMATED FIRST COSTS
AND
ANNUAL CHARGES

(UPLAND DISPOSAL)

	Item	Total Waterway	Cooper River	Shipyard River
38-Foot Project	Federal First Costs	$ 33,314,000	$ 29,856,000	$ 3,458,000
	Non-Federal First Costs	5,390,000	3,577,000	1,813,000
	Total First Costs	$ 38,704,000	$ 33,433,000	$ 5,271,000
	Annual Charges			
	Federal	$ 5,070,000	$ 4,079,000	$ 991,000
	Non-Federal	755,000	491,000	264,000
	TOTAL	$ 5,825,000	$ 4,570,000	$ 1,255,000
40-Foot Project	Federal First Costs	$ 50,988,000	$ 46,942,000	$ 4,046,000
	Non-Federal First Costs	7,337,000	4,965,000	2,372,000
	Total First Costs	$ 58,325,000	$ 51,907,000	$ 6,418,000
	Annual Charges			
	Federal	$ 7,449,000	$ 6,068,000	$ 1,381,000
	Non-Federal	945,000	634,000	311,000
	TOTAL	$ 8,394,000	$ 6,702,000	$ 1,692,000
42-Foot Project	Federal First Costs	$ 71,023,000	$ 65,997,000	$ 5,026,000
	Non-Federal First Costs	8,606,000	6,354,000	2,252,000
	Total First Costs	$ 79,629,000	$ 72,351,000	$ 7,278,000
	Annual Charges			
	Federal	$ 9,873,000	$ 8,297,000	$ 1,576,000
	Non-Federal	1,115,000	771,000	344,000
	TOTAL	$ 10,988,000	$ 9,068,000	$ 1,920,000

maps contained channel layouts and the results of the latest hydrographic surveys. Once the hydrographic survey information was placed on the maps, the channel designs were laid out, as well as all other pertinent information, such as areas requiring annual maintenance, areas which are overdredged in the interest of advanced maintenance, etc. Representative stations were chosen for use in volume computations. The basic information at each representative station was coded for use with one of a number of computer programs depending on which program best fit the situation. The computer program input was coded so that the volume of material could be computed in one-foot increments of depth starting at 37 feet mean low water. With minor revisions to the input data, volume computations could be made for a number of different channel designs. The following conditions were assumed in making the dredging computations: (1) the authorized project is maintained at 35 feet plus two feet allowable overdepth; incremental depths will require the removal of material to that depth plus two feet; i.e., a 40-foot project would require the removal of material from 37 feet to 42 feet; (2) advanced maintenance will be continued where now practiced; incremental depth will require removal of material to the depth under study, plus the added depth for advanced maintenance, plus two feet for allowable overdepth; i.e., in reaches requiring four feet advanced maintenance, a 40-foot project would require the removal of material to 46 feet. Table C-9 summarizes the volume of material (Federal) to be removed for the depths indicated.

35. The volumes of material (non-Federal) to be removed from dockside vessel mooring areas for the indicated project depth are given in Table C-10.

TABLE C-9
FEDERAL
INITIAL VOLUME QUANTITIES, AUTHORIZED NAVIGATION CHANNELS

(Includes 2' for Overdepth, Volume in 1,000 yd^3)

Station	Inland Channels	38'	40'	42'
	Entrance Channel	40'	42'	44'
		Volume (Cu. Yds.)		
ENTRANCE CHANNEL				
Sta -671+00 to Sta -290+00		616	821	1,155
Sta -290+00 to Sta 300+00		7,180	11,274	15,757
Subtotal		7,796	12,095	16,912
ANCHORAGE BASIN				
Enlarged Anchorage Basin		1,421	2,383	3,348
MOUNT PLEASANT RANGE STA 300+00 TO MYERS BEND 760+50				
Sta 300+00 to Sta 355+20		12	35	66
Sta 355+20 to Sta 469+62		563	1,079	1,654
Sta 470+00 to Sta 502+54		174	334	511
Sta 502+84 to Sta 520+62		115	217	329
Sta 520+62 to Sta 546+42		48	138	299
Sta 546+42 to Sta 563+00		10	55	133
Sta 563+00 to Sta 572+37 [1]		65	110	157
Sta 634+80 to Sta 665+00		209	357	512
Sta 665+00 to Sta 700+10		38	134	251
Sta 702+20 to Sta 710+30		19	42	80
Sta 710+30 to Sta 744+00 [3]		205	368	544
Sta 744+80 to Sta 760+50		30	113	209
Subtotal		1,488	2,982	4,745
CUSTOM HOUSE REACH - TOWN CREEK TO MYERS BEND				
Triangular Shaped Piece Custom House Reach		21	51	86
Tidewater Reach Sta 0+00 to Sta 10+00		142	197	255
Tidewater Reach Sta 10+00 to Sta 44+00 [1]		514	765	1,061
Town Creek Lower Sta 21+00 to Sta 67+00 [1]		415	635	848
Town Creek Lower Sta 67+00 to Sta 84+36		8	23	62
Town Creek Upper Sta 84+36 to Sta 97+76 [1]		54	90	132
Town Creek Upper Sta 97+76 to Sta 135+02 [1]		289	465	649
Turning Basin at Columbus Street [2]		915	1,007	1,097
Subtotal		2,358	3,233	4,190
MYERS BEND STA 760+50 TO HEAD OF COMMERCIAL PROJECT STA 1,154+60				
Sta 760+50 to Sta 773+44		9	21	38
Sta 773+44 to Sta 788+00		6	30	80
Sta 788+00 to Sta 826+00 [1]		270	462	661
Sta 826+00 to Sta 874+50		111	279	530
Sta 874+50 to Sta 896+00 [3]		148	252	360
Sta 896+00 to Sta 928+11		41	176	336
Sta 925+61 to Sta 949+97		49	119	213
Sta 952+74 to Sta 959+66		12	20	33
Sta 959+64 to Sta 992+23 [2]		261	442	629
Sta 992+23 to Sta 1,027+00 (500 ft channel)		271	428	594
Sta 1,027+00 to Sta 1,056+00 (500 ft channel) [2]		152	236	323
Sta 1,056+50 to Sta 1,100+13 (500 ft channel)		501	696	897
Sta 1,100+80 to Sta 1,134+90 (500 ft channel) [3]		290	469	654
Sta 1,135+50 to Sta 1,154+60 (500 ft channel) [3]		110	224	339
Subtotal		2,231	3,854	5,687
TOTAL	35'	15,294	24,547	34,882
SHIPYARD RIVER				
Sta 3+00 to Sta 24+25 [4]	267	430	540	653
Sta 24+25 to Sta 28+25 [4]	74	131	149	167
Sta 27+00 to Sta 38+60 [4]	361	555	647	721
Sta 38+60 to Sta 58+25 [4]	330	404	619	649
Sta 58+25 to End of TB [4]	640	1,010	1,108	1,189
TOTAL	1,672	2,530	3,063	3,379

[1] Overdredged 4' for adv. maint.
[2] Overdredged 3' for adv. maint.
[3] Overdredged 2' for adv. maint.
[4] Overdredged 6' for adv. maint.

TABLE C-10

NON-FEDERAL

INITIAL VOLUME QUANTITIES - DOCK & BERTHING AREAS
(Includes 2' for Overdepth, Volume in 1,000 yd^3)

	35	38	40	42
Union Street				
Sta 10+00 to Sta 37+20		23	34	57
Columbus Street				
Sta 35+90 to Sta 51+40		17	26	36
Sta 51+40 to Sta 74+70		9	19	36
North Charleston Reach		41	69	96
Filbin Creek Reach		89	126	165
Port Terminal Reach		70	114	153
Shipyard River	118	176	210	240

MARL VOLUMES

36. As indicated on the logs of borings, Figures C-7 and C-8, marl is expected to be encountered in some areas when the channel is deepened. The depth at which it will be encountered varies, but once encountered will extend the total depth of any presently conceived dredging operation. In order for realistic cost estimates to be made, it was necessary to calculate the volumes of marl and the volume of soft material which is to be removed from the channels. To make a distinction, a multitude of information was assembled which included the results of current and previous borings, probes, etc., conducted by the Corps of Engineers, similar information contiguous to the Cooper River, but conducted by others after dredging condition surveys where it was known marl had been dredged from the channel, i.e., for construction of the contraction dikes and Daniel Island disposal area dikes, and seismic survey work performed for use in the Estuarine Values Study portion of this report. Where possible this information was depicted on the base maps. A review of the above information revealed that except for a few isolated areas, no marl should be encountered in the entrance channel or in the lower harbor below Myers Bend (upper end of Drum Island) above -50 feet mean low water. Above Myers Bend, the depth at which marl will be encountered varies from -40 to -50 feet mean low water. For the most part, the representative stations used for computing the total volume computations were used in computing the marl volumes, the only difference being in the cross-sectional information. The marl volumes were computed using the same computer programs used to compute the total volume. The volume of soft material and the volume of marl to be removed for the depths indicated are summarized in Tables C-11, C-12, and C-13, respectively, for the Federal and non-Federal dredging.

TABLE C-11

FEDERAL INITIAL VOLUME QUANTITIES - EXCLUDING MARL
(INCLUDES 2' FOR OVERDEPTH, VOLUME IN 1,000 YD[3/])

Station	Volume (Cu. Yds.)			
	Inland Channels	35	38	40	42
	Entrance Channel	35	40	42	44
ENTRANCE CHANNEL				
Sta -671+00 to Sta -290+00		616	821	1,155
Sta -290+00 to Sta 300+00		7,180	11,274	15,757
ANCHORAGE BASIN				
Enlarged Anchorage Basin		1,421	2,383	3,348
MOUNT PLEASANT RANGE STA 300+00 TO MYERS BEND STA 760+50				
Sta 300+00 to Sta 355+20		12	35	66
Sta 355+20 to Sta 469+62		563	1,079	1,654
Sta 470+00 to Sta 502+54		174	334	511
Sta 502+84 to Sta 520+62		115	217	329
Sta 520+62 to Sta 546+62		48	138	299
Sta 546+42 to Sta 563+00		10	55	133
Sta 563+00 to Sta 572+37 [1/]		65	110	157
Sta 634+80 to Sta 665+00 [1/]		209	277	277
Sta 665+00 to Sta 700+10		38	134	251
Sta 702+20 to Sta 710+30		19	42	80
Sta 710+30 to Sta 744+00 [3/]		205	368	544
Sta 744+100 to Sta 760+50		30	112	209
CUSTOM HOUSE REACH, TOWN CREEK TO MYERS BEND				
Triangular shaped area at Custom House Reach		21	51	86
Tidewater Reach Sta 0+00 to Sta 10+00		142	197	255
Tidewater Reach Sta 10+00 to Sta 44+00 [1/]		514	765	1,061
Town Creek Lower Sta 21+00 to Sta 67+00 [1/]		415	635	848
Town Creek Lower Sta 67+00 to Sta 84+36		8	23	62
Town Creek Upper Sta 84+36 to Sta 97+76 [1/]		54	90	132
Town Creek Upper Sta 97+76 to Sta 135+02 [1/]		289	398	508
Turning Basin at Columbus Street [1/]		915	1,007	1,097
MYERS BEND STA 760+50 - TO HEAD OF COMMERCIAL PROJECT - STA 1,154+60				
Sta 760+50 to Sta 773+44		8	17	27
Sta 773+44 to Sta 788+00		3	11	24
Sta 788+00 to Sta 826+00 [1/]		233	353	414
Sta 826+00 to Sta 874+50		85	160	244
Sta 874+50 to Sta 896+00 [3/]		24	45	67
Sta 896+00 to Sta 928+11		41	176	336
Sta 925+61 to Sta 949+97		49	119	213
Sta 952+74 to Sta 959+66		12	20	33
Sta 959+66 to Sta 992+23 [2/]		261	442	629
Sta 992+23 to Sta 1,027+00		271	375	486
Sta 1,027+00 to Sta 1,056+00 [2/]		98	121	133
Sta 1,056+50 to Sta 1,100+13		501	696	897
Sta 1,100+80 to Sta 1,134+90 [3/]		290	468	610
Sta 1,135+50 to Sta 1,154+60 [3/]		110	224	339
SHIPYARD RIVER				
Sta 3+00 to Sta 24+25 [4/]		94	116	120	122
Sta 24+25 to Sta 28+25 [4/]		62	96	99	100
Sta 27+00 to Sta 38+60 [4/]		295	428	463	478
Sta 38+60 to Sta 58+25 [4/]		297	340	513	506
Sta 58+25 to End of Turning Basin [4/]		528	803	841	864

1/ Overdredged 4' for adv. maint.
2/ " 3' " " "
3/ " 2' " " "
4/ " 6' " " "

TABLE C-12

FEDERAL
INITIAL VOLUME QUANTITIES, EXISTING PROJECT - MARL ONLY
(Includes 2' for Overdepth, Volume in 1,000 yd^3)

Station	Volume (Cu. Yds.)			
Inland Channels	35	38	40	42
Entrance Channel	35	40	42	44
ENTRANCE CHANNEL				
Sta -671+00 to Sta 300+00	NO MARL			
MOUNT PLEASANT RANGE - STA 300+00 TO MYERS BEND STA 760+50				
Sta 300+00 to Sta 502+54	NO MARL			
Sta 502+84 to Sta 520+62	-	-	-	-
Sta 520+62 to Sta 572+37	NO MARL			
Sta 634+80 to Sta 665+00 1/	-	-	80	235
Sta 665+00 to Sta 760+50	NO MARL			
CUSTOM HOUSE REACH, TOWN CREEK TO MYERS BEND				
Sta 0+00 to Sta 97+76	NO MARL			
Sta 97+76 to Sta 135+02 1/	-	-	67	141
MYERS BEND STA 760+50 - TO HEAD OF COMMERCIAL PROJECT STA 1,154+60				
Sta 760+50 to Sta 773+44	-	1	4	11
Sta 773+44 to Sta 788+00	-	3	19	56
Sta 788+00 to Sta 826+00 1/	-	37	109	247
Sta 826+00 to Sta 874+50	-	26	119	286
Sta 874+50 to Sta 896+00 3/	-	124	207	293
Sta 896+00 to Sta 928+11	NO MARL			
Sta 925+61 to Sta 949+97	NO MARL			
Sta 952+74 to Sta 959+66	NO MARL			
Sta 959+64 to Sta 992+23 2/	NO MARL			
Sta 992+23 to Sta 1,027+00	-	-	53	108
Sta 1,027+00 to Sta 1,056+00 2/	-	54	115	190
Sta 1,056+50 to Sta 1,100+13	-	-	-	-
Sta 1,100+80 to Sta 1,134+90 3/	-	-	1	44
Sta 1,135+50 to Sta 1,154+60 3/	NO MARL			
SHIPYARD RIVER				
Sta 3+00 to Sta 24+25 4/	173	313	421	531
Sta 24+25 to Sta 28+25 4/	12	35	50	66
Sta 27+00 to Sta 38+60 4/	66	127	183	243
Sta 38+60 to Sta 58+25 4/	33	64	106	143
Sta 58+25 to End of Turning Basin 4/	112	206	267	325

1/ Overdredged 4' for adv. maint.
2/ Overdredged 3' for adv. maint.
3/ Overdredged 2' for adv. maint.
4/ Overdredged 6' for adv. maint.

TABLE C-13

NON-FEDERAL

INITIAL VOLUME QUANTITIES, EXCLUDING MARL - DOCK & BERTHING AREAS
(Includes 2' for Overdepth, Volume in 1,000 yd^3)

	35	38	40	42
Union Street				
Sta 10+00 to Sta 37+20	-	23	34	57
Columbus Street				
Sta 35+90 to Sta 51+40	-	17	26	36
Sta 51+40 to Sta 74+70	-	9	19	36
North Charleston Reach	-	30	50	70
Filbin Creek Reach	-	89	126	165
Port Terminal Reach	-	63	88	108
Shipyard River	118	148	148	148

INITIAL VOLUME QUANTITIES, MARL ONLY - DOCKS & BERTHING AREAS
(Includes 2' for Overdepth Volume in 1,000 yd^3)

	38	40	42
Union Street			
Sta 10+00 to Sta 37+20	----------NO MARL----------		
Columbus Street			
Sta 35+90 to Sta 51+40	----------NO MARL----------		
Sta 51+40 to Sta 74+70	----------NO MARL----------		
North Charleston Reach	11	19	26
Filbin Creek Reach			
Sta 1056+50 to Sta 1100+13	-	-	-
Port Terminal	7	26	45
Shipyard River	28	62	92

MAINTENANCE

37. The estimated annual maintenance cost is for the increased quantity of material to be removed resulting from implementation of considered improvements; i.e., the amount in excess of the present maintenance requirements. The volume of maintenance material is computed based on the following assumptions: (a) present shoaling rates would remain constant until rediversion of the freshwater discharges through Pinopolis Dam is accomplished, (b) for increased channel widths the shoaling will increase directly proportional to the channel-bottom surface area, (c) for increased channel depths the shoaling will increase as the square of the ratio of the new depth to the existing depth, and (d) shoaling in the various channel reaches will decrease exponentially for a 10-year transition period after completion of the Cooper River Rediversion Project.

RECOMMENDED PLAN

38. Detailed estimates of first costs and annual charges for work required on Cooper River and Shipyard River included in the recommended plan are shown in Tables C-14 through C-17. The estimates of first cost include the cost of construction, lands and damages, engineering and design, and supervision and administration. Estimates of annual charges include interest and amortization of the investment over a 50-year period, and additional annual maintenance costs of the modifications to the waterway project. For computing the Federal and non-Federal annual charges, an interest rate of 7.125 percent was used.

TABLE C-14

ESTIMATES OF FIRST COST
SHIPYARD RIVER 38 FT. PROJECT
UPLAND DISPOSAL

ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT
FEDERAL FIRST COST				
Corps of Engineers				
Channels (Dredging)				
Mob. and Demob.	Job	1	Lump Sum	$ 50,000
Excavation	CY	2,530,000	$1.05	2,657,000
Subtotal, Channels				2,707,000
Contingencies				406,000
Construction Cost, Channels				3,113,000
Engineering and Design				156,000
Supervision and Administration				187,000
Total, Corps of Engineers				$3,456,000
U. S. Coast Guard				
Navigational Aids	Job	1	Lump Sum	2,000
Total Federal First Cost				$3,458,000
NON-FEDERAL FIRST COST				
Berthing Areas (Dredging)				
Mob. and Demob.	Job	1	Lump Sum	$ 20,000
Excavation	CY	176,000	$1.40	246,000
Subtotal, Berthing Areas				266,000
Contingencies				40,000
Construction Cost, Berthing Areas				306,000
Engineering and Design				15,000
Supervision and Administration				18,000
Total, Berthing Areas				$339,000

TABLE C-14 (CONT.)

ESTIMATES OF FIRST COST
SHIPYARD RIVER 38 FT. PROJECT
UPLAND DISPOSAL

ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT
NON-FEDERAL FIRST COST (CONT.)				
Disposal Area Preparation				
Diking	Job	1		$678,000
Spillways	Job	1		20,000
Subtotal				698,000
Contingencies				105,000
Construction Cost				803,000
Engineering and Design				40,000
Supervision and Administration				48,000
Total, Disposal Area Preparation				$891,000
Lands and Damages				
Land	Acre	194	$2,000	$388,000
Severance Damage	Job	1		39,000
Acquisition Cost	Job	1		39,000
Subtotal				$466,000
Contingencies				117,000
Total, Lands and Damages				$583,000
Total, Non-Federal First Cost				$1,813,000
Summary of First Cost				
Federal -((3,458,000 - (.05 X 5,271,000))				$3,194,000
Non-Federal -((1,813,000 + (.05 X 5,271,000))				2,077,000
Total First Cost				$5,271,000

TABLE C-15

ESTIMATES OF FIRST COST
COOPER RIVER 40 FT. PROJECT
UPLAND DISPOSAL

ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT
FEDERAL FIRST COST				
Corps of Engineers				
Channels (Dredging)				
Mob. and Demob.	Job	1	Lump Sum	$ 500,000
Entrance Channel	CY	12,095,000	$1.90	$22,981,000
Anchorage Basin	CY	2,383,000	$1.30	$ 3,098,000
Main Channel:				
Mt. Pleasant Range to Myers Bend	CY	2,982,000	$1.25	$ 3,728,000
Custom House Reach, Town Creek to Myers Bend	CY	3,233,000	$1.00	$ 3,233,000
Myers Bend to Head of Project	CY	3,854,000	$1.10	$ 4,239,000
Subtotal, Channels				$37,779,000
Contingencies				$ 5,667,000
Construction Cost, Channels				$43,446,000
Engineering and Design				$ 1,738,000
Supervision and Administration				$ 1,738,000
Total, Corps of Engineers				$46,922,000
U. S. Coast Guard				
Navigational Aids	Job	1	Lump Sum	$ 20,000
Total First Federal Cost				$46,942,000
NON-FLDERAL FIRST COST				
Berthing Areas (dredging)				
Mob. and Demob.	Job	1	Lump Sum	$ 50,000
Excavation	CY	388,000	$1.10	$ 427,000
Subtotal, Berthing Areas				$ 477,000
Contingencies				$ 72,000
Construction Cost, Berthing Areas				$ 549,000
Engineering and Design				$ 27,000
Supervision and Administration				$ 33,000
Total, Berthing Areas				$ 609,000
Disposal Area Preparation				
Diking	Job	1	Lump Sum	$ 1,730,000
Spillways	Job	1	Lump Sum	$ 70,000
Subtotal				$ 1,800,000
Contingencies				$ 270,000
Construction Cost				$ 2,070,000
Engineering and Design				$ 104,000
Supervision and Administration				$ 124,000
Total, Disposal Area Preparation				$ 2,298,000

TABLE C-15 (Cont.)

ESTIMATES OF FIRST COST
COOPER RIVER 40 FT. PROJECT
UPLAND DISPOSAL

ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT
Lands and Damages				
Lands				
Anchorage Basin	Acre	175	$ 500	$ 88,000
Cooper River	Acre	755	$1,700	$ 1,284,000
Severance Damage	Job	1	Lump Sum	$ 137,000
Acquisition Cost	Job	1	Lump Sum	$ 137,000
Subtotal				$ 1,646,000
Contingencies				$ 412,000
Total, Lands and Damages				$ 2,058,000
Total Non-Federal First Cost				$ 4,965,000
SUMMARY OF FIRST COST				
Federal				$46,942,000
Non-Federal				$ 4,965,000
Total First Cost				$51,907,000
ADJUSTED FIRST COST				
Federal ($46,942,000 - $2,595,000)				$44,347,000
Non-Federal ($4,965,000 + $2,595,000)				$ 7,560,000
Total Adjusted First Cost				$51,907,000

TABLE C-16

ESTIMATES OF ANNUAL CHARGES
SHIPYARD RIVER - 38 FT. PROJECT
UPLAND DISPOSAL

ITEM	AMOUNT
Federal Investment	
Corps of Engineers	
Estimated First Cost	$3,456,000
Interest During Construction	None
Corps of Engineers Investment	3,456,000
U. S. Coast Guard	
Navigation Aids	$ 2,000
Non-Federal Portion of Total First Cost	-$ 264,000
Total Federal Investment	$3,194,000
Non-Federal Investment	
Estimated First Cost	$1,813,000
Interest During Construction	None
Non-Federal Portion of Total First Cost	264,000
Total Non-Federal Investment	$2,077,000
Federal Annual Charges	
Interest on Investment (7.125%)	$ 227,000
Amortization (50 Years) (.002347)	7,000
Maintenance	737,000
Total Federal Annual Charge	$ 971,000
Non-Federal Annual Charges	
Interest on Investment	$ 148,000
Amortization (50 Years)	5,000
Maintenance	131,000
Total Non-Federal Annual Charges	$ 284,000
Total Annual Charges	
Federal	$ 971,000
Non-Federal	284,000
Total Annual Charges	$1,255,000

TABLE C-17

ESTIMATES OF ANNUAL CHARGES
CHARLESTON HARBOR - 40 FT. PROJECT
UPLAND DISPOSAL

ITEM	AMOUNT
Federal Investment	
Corps of Engineers	
Estimated First Cost	$46,922,000
Interest During Construction	None
Corps of Engineers Investment	$46,922,000
U. S. Coast Guard	
Navigation Aids	$ 20,000
Non-Federal Portion of Total First Cost	-$ 2,595,000
Total Federal Investment	$44,347,000
Non-Federal Investment	
Estimated First Cost	$ 4,965,000
Interest During Construction	None
Non-Federal Portion of Total First Cost	$ 2,595,000
Non-Federal Investment	$ 7,560,000
Federal Annual Charges	
Interest on Investment (7.125%)	$ 3,160,000
Amortization (50 Years) (.002357)	105,000
Maintenance	2,609,000
Aids to Navigation	3,000
Total Federal Annual Charges	$ 5,877,000
Non-Federal Annual Charges	
Interest on Investment (7.125%)	$ 539,000
Amortization (50 Years)	18,000
Maintenance	268,000
Total Non-Federal Annual Charges	$ 825,000
Total Annual Charge	
Federal	$5,877,000
Non-Federal	825,000
Total Annual Charges	$6,702,000

39. Contingency allowances of 15 percent for dredging and 25 percent for lands are included in the cost estimates. Unit prices used in the cost estimates are based on the average prevailing construction costs for the area as of February 1980. Estimates for dredging of the inland channels and basins are based on the use of a 27-inch pipeline dredge for initial dredging and an 18-inch pipeline dredge for maintenance dredging. About 75% of the initial dredging is to be deposited in the Daniel Island disposal area and 25% in the Clouter Creek disposal area. Pumping distances for the various reaches range from 5,000 feet to 37,000 feet and the number of booster pumps used varies from zero to two. Approximately 15% of the material to be excavated is classified as marl. About 65% of the maintenance dredging is to be deposited in the Daniel Island disposal area, 15% in the Clouter Creek disposal area, and 20% in the Morris Island disposal area. Pumping distances for the various reaches range from 3,000 feet to 16,000 feet and in some reaches one booster pump is required. Estimates for dredging the jetty and entrance channels are based on the use of the Corps of Engineers' hopper dredges. Disposal area requirements were based on an average allowance of 16,000 cubic yards of material being placed on one acre of diked disposal area (10 feet high). The location of possible disposal areas used for these cost estimates is shown on Figure C-11; however, other suitable sites are available in the area. Ocean disposal is considered as an alternative to upland disposal. Cost estimates were prepared based on the removal of the material by a special dredge, pumping the dredged material into hopper barges located alongside the dredge and transporting the material to the Atlantic Ocean by the barges for disposal. These cost estimates were based on cost data developed by the Mobile District for the Mobile Harbor Study. The availability of the special equipment at the time the harbor is modified is the major concern in the use of this plan. The estimated first costs using ocean disposal for 40-foot Charleston Harbor Project and the 38-foot Shipyard River Project are found on Tables C-18 and C-19, respectively. Annual charges are found on Tables C-20 and C-21.

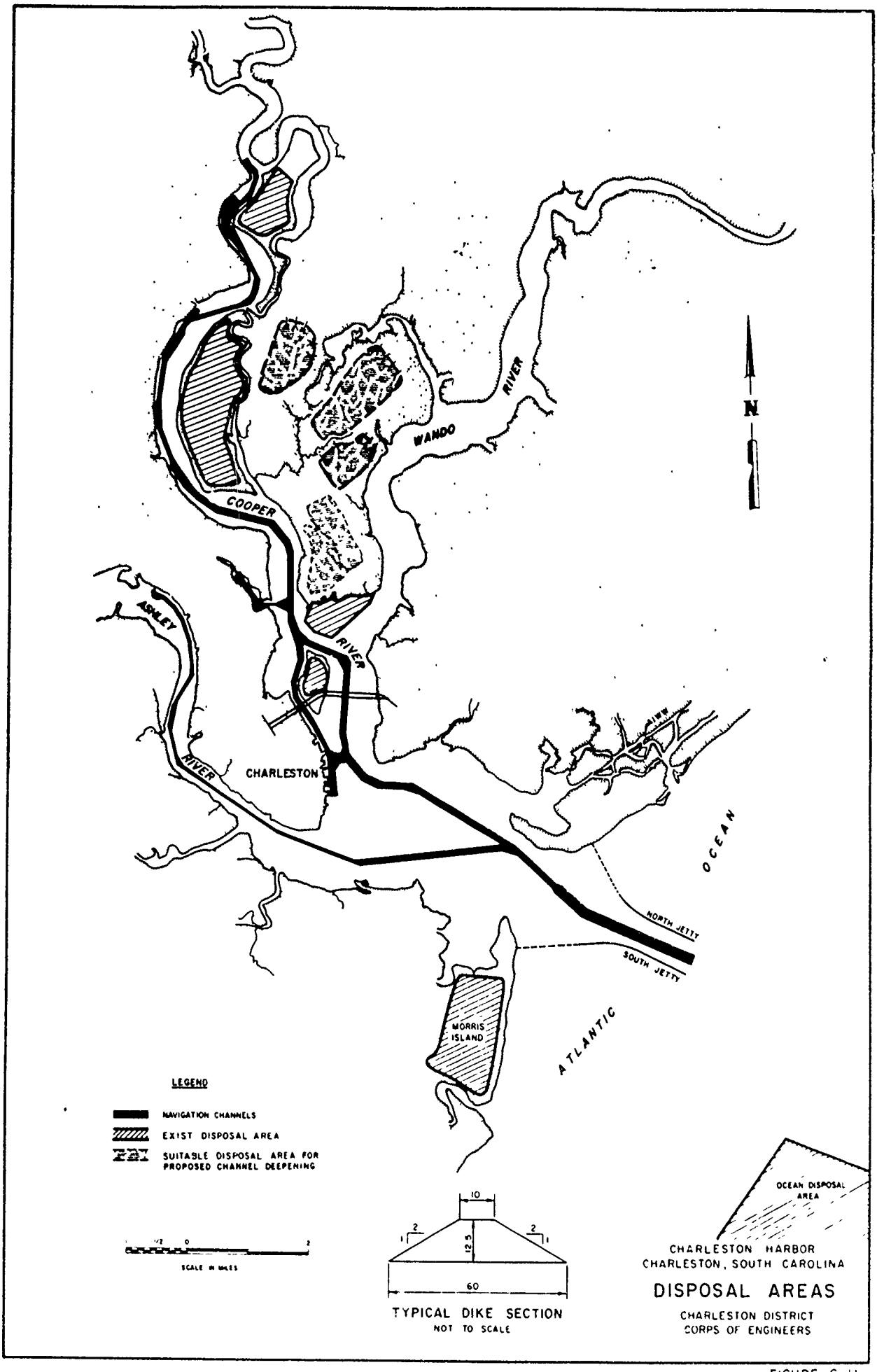

WANDO RIVER
COOPER RIVER
ASHLEY RIVER
CHARLESTON
N
OCEAN
NORTH JETTY
SOUTH JETTY
ATLANTIC
MORRIS ISLAND
LEGEND
NAVIGATION CHANNELS
EXIST DISPOSAL AREA
SUITABLE DISPOSAL AREA FOR PROPOSED CHANNEL DEEPENING
SCALE IN MILES
10
2
2
1
1
12.5
60
TYPICAL DIKE SECTION
NOT TO SCALE
OCEAN DISPOSAL AREA
CHARLESTON HARBOR
CHARLESTON, SOUTH CAROLINA
DISPOSAL AREAS
CHARLESTON DISTRICT
CORPS OF ENGINEERS

FIGURE C-11

TABLE C-18

ESTIMATES OF FIRST COST
COOPER RIVER - 40 FT. PROJECT
OCEAN DISPOSAL

ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT
FEDERAL FIRST COST				
Corps of Engineers				
Channel	CY	24,547,000	$1.80	$44,185,000
Contingencies				6,628,000
Construction Cost				50,813,000
Engineering and Design				2,033,000
Supervision and Administration				2,033,000
Total, Corps of Engineers				$54,879,000
U. S. Coast Guard				
Navigation Aids				$ 20,000
Total Federal				$54,899,000
NON-FEDERAL FIRST COST				
Berthing Areas	CY	388,000	$1.80	$ 698,000
Contingencies				105,000
Construction Cost				$ 803,000
Engineering and Design				48,000
Supervision and Administration				48,000
Total Non-Federal				$ 899,000
ADJUSTED FIRST COST				
Federal ((54,899,000 - (55,798,000 X .05))				$52,109,000
Non-Federal ((899,000 + (55,798,000 X .05))				3,689,000
Total First Cost				$55,798,000

TABLE C-19

ESTIMATES OF FIRST COST
SHIPYARD RIVER - 38 FT. PROJECT
OCEAN DISPOSAL

ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT
FEDERAL FIRST COST				
Corps of Engineers				
Channel	CY	2,530,000	$1.80	$4,554,000
Contingencies				683,000
Construction Cost				5,237,000
Engineering and Design				262,000
Supervision and Administration				314,000
Total COE				$5,813,000
U. S. Coast Guard				
Navigation Aids				$ 2,000
Total Federal				$5,815,000
NON-FEDERAL FIRST COST				
Berthing Areas	CY	176,000	$1.80	$317,000
Contingencies				48,000
Engineering and Design				22,000
Supervision and Administration				22,000
Total Non-Federal				$409,000
ADJUSTED FIRST COST				
Federal ((5,815,000 - (6,224,000 X .05))				$5,504,000
Non-Federal ((409,000 + (6,224,000 X .05))				720,000
Total First Cost				$6,224,000

TABLE C-20

ESTIMATES OF ANNUAL CHARGES
COOPER RIVER - 40' PROJECT
OCEAN DISPOSAL

ITEM	COST
Federal Investment	
Corps of Engineers	
Estimated First Cost	$ 54,879,000
Interest During Construction	NONE
TOTAL CORPS OF ENGINEERS INVESTMENT	$ 54,879,000
U.S. Coast Guard	$ 20,000
Non-Federal Portion of Total First Cost (5%)	- 2,790,000
TOTAL FEDERAL INVESTMENT	$ 52,109,000
Non-Federal Investment	
Estimated First Cost	$ 899,000
Interest During Construction	NONE
Non-Federal Portion of First Cost (5%)	2,790,000
TOTAL NON-FEDERAL INVESTMENT	$ 3,689,000
Federal Annual Charges	
Interest on Investment	$ 3,712,000
Amortization	123,000
Maintenance	1,981,000
Aids to Navigation	3,000
TOTAL FEDERAL ANNUAL CHARGES	$ 5,819,000
Non-Federal Annual Charges	
Interest on Investment	$ 263,000
Amortization	9,000
Maintenance	91,000
TOTAL NON-FEDERAL ANNUAL CHARGES	$ 363,000
Total Annual Charges	
Federal	$ 5,819,000
Non-Federal	363,000
TOTAL ANNUAL CHARGES	$ 6,182,000

TABLE C-21

ESTIMATES OF ANNUAL CHARGES
SHIPYARD RIVER - 38' PROJECT
OCEAN DISPOSAL

ITEM	COST
Federal Investment	
Corps of Engineers	
Estimated First Cost	$ 5,815,000
Interest During Construction	NONE
Non-Federal Portion of Total First Cost	311,000
TOTAL FEDERAL INVESTMENT	$ 5,504,000
Non-Federal Investment	
Estimated First Cost	$ 409,000
Interest During Construction	NONE
Non-Federal Portion of First Cost	311,000
TOTAL NON-FEDERAL INVESTMENT	$ 720,000
Federal Annual Charges	
Interest on Investment	$ 392,000
Amortization	13,000
Maintenance	995,000
TOTAL FEDERAL ANNUAL CHARGES	$ 1,400,000
Non-Federal Annual Charges	
Interest on Investment	$ 51,000
Amortization	2,000
Maintenance	NONE
TOTAL NON-FEDERAL ANNUAL CHARGES	$ 53,000
Total Annual Charge	
Federal	$ 1,400,000
Non-Federal	53,000
TOTAL ANNUAL CHARGES	$ 1,453,000

APPENDIX D
FORMULATION, ASSESSMENT, AND EVALUATION OF DETAILED PLAN

APPENDIX D
FORMULATION, ASSESSMENT AND EVALUATION OF DFTAILED PLAN

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APPENDIX D
FORMULATION, ASSESSMENT AND EVALUATION OF DETAILED PLAN

Introduction

1. This appendix contains the necessary information for the formulation of the selected plan. This information includes a sensitivity analysis of the projection of critical commodities handled over terminals located on Cooper and Shipyard Rivers. It also discusses the decision process and trade-off analysis for the selection of a plan for implementation.

Comparison of Plans

COOPER RIVER

2. Three plans of modification, varying only in project depth, (38, 40 and 42) feet were compared. Each plan included the following items of commensurate depth with the project depth being considered:

(a) Modification of the turning basin adjacent to the Columbus Street docks with a turning diameter of 1,200 feet.

(b) Enlargement of the existing turning basin at the head of commercial navigation (Goose Creek) to provide a 1,200-foot diameter.

(c) Enlargement of the anchorage basin by extending the south side of the basin 1,400 feet.

(d) Realignment of the channel centerline to provide 125 feet between existing docks, piers, etc., and the edge of the channel.

(e) Easing of the bend at the northern approach to the Cooper River Bridge.

(f) Widening of the Filbin Creek and North Charleston reaches to 500 feet.

SHIPYARD RIVER

3. It was considered necessary to independently analyze and determine the economic justification of deepening Shipyard River from 30 to 35 feet (mlw), the existing project depth in Charleston Harbor. If deepening to 35 feet is justifiable, the incremental evaluation of additional deepening to 38, 40 and 42 feet would be considered. Each plan considered enlargement of the upper and lower turning basins and widening the connecting channel to 250 feet.

Selection of Plan

GENERAL

4. Selection of the recommended plan was based on comparing the plans discussed previously to determine the optimum scale of improvement from an economic standpoint.

COOPER RIVER

5. The estimated annual equivalent benefit, annual projected cost, excess benefits over cost, and benefit to cost ratio are presented in Table D-1 for modified project depths of 38, 40 and 42 feet.

TABLE D-1
PLAN FORMULATION[1/]
COOPER RIVER

Project Depth	Annual Equivalent Benefits	Annual Charges	Excess Benefits Over Cost	B/C Ratio
38	8,697	4,570	4,127	1.90
40	12,297	6,702	5,595	1.83
42	13,781	9,068	4,713	1.52

[1/] $1,000 rounded

6. The optimum plan from an economic standpoint for Cooper River is a 40-foot project. The incremental excess annual benefit between a 38-foot project and a 40-foot project is $1,525,000 or an incremental benefit to cost ratio between these two depths of 1.73. It should be remembered, however, that the container benefits for Cooper River consider only the future tonnage that can be handled by existing facilities. Since these terminals are already approaching full capacity, additional facilities are certain to be constructed. At the time the survey report was submitted, the Ports Authority estimated that their existing facilities had a capacity of 1,300,000 tons; however, this figure was topped in 1976, 1977 and 1978. For the twelve-month period extending from June 1978 through May 1979, approximately 1,900,000 tons of merchandise were handled by containership. Based on this tonnage, the 2,000,000 ton capacity assumed in this report also appears to be conservative.

7. Since the latest oil crisis has brought home to the American people a greater need to conserve energy, a sensitivity analysis was prepared on petroleum products. Table D-2 shows the effects on proposed Cooper River modifications if there is no increase in the petroleum commerce over the life of the project. This table shows that under these conditions the proposed 40-foot project would have a B/C ratio of 1.6. Further analysis showed that even if existing petroleum products were reduced 55 percent, the 40-foot project would still be economically justifiable.

TABLE D-2
Sensitivity Analysis[1/]
Cooper River

Project Depth	Annual Equivalent Benefits	Annual Charges	Excess Benefits Over Cost	B/C Ratio
38	7,368	4,570	2,798	1.6
40	10,604	6,702	3,902	1.6
42	11,939	9,068	2,871	1.3

[1/] $1,000 rounded

SHIPYARD RIVER

8. Table D-3 displays the estimated annual equivalent benefit, annual projected cost, excess benefits over cost and benefit to cost ratio for deepening Shipyard River to depths of 35, 38, 40 and 42 feet.

TABLE D-3
PLAN FORMULATION[1/]
SHIPYARD RIVER

Project Depth	Annual Equivalent Benefits	Annual Charges	Excess Benefits Over Cost	B/C Ratic
30-35	3,235	772	2,463	4.19
35-38	1,396	483	913	2.89
35-40	1,792	920	872	1.95
35-42	1,897	1,148	789	1.65

[1/] $1,000 rounded

9. For Shipyard River the optimum plan from an economic standpoint is the 38-foot project. The incremental annual benefit between a 35-foot project and the 38-foot project is $913,000 or an incremental benefit to cost ratio of 2.89.

10. A sensitivity analysis on chrome ore and petroleum commerce was done for Shipyard River. Table D-4 shows the effects of the project: (a) without any increase in petroleum commerce; (b) with the elimination of chrome ore; and, (c) with the elimination of chrome ore and without increase in petroleum commerce. The elimination of chrome ore would not require any modification past the lower turning basin, thus the decrease in annual cost. Further sensitivity analysis shows that the 35-foot and 38-foot projects do not require any petroleum commerce to be economically justified. Elimination of the chrome ore commerce will only change the needs to Shipyard River by eliminating the usefulness of a deeper channel above the lower turning basin.

TABLE D-4

Sensitivity Analysis[1/]

Shipyard River

Project Depth	Annual Equivalent Benefits	Annual Charges	Excess Benefits Over Cost	B/C Ratio
		Without Increase in Petroleum		
35	2,922	772	2,150	3.78
38	1,231	483	748	2.55
		Without Chrome Ore		
35	1,347	258[2/]	1,089	5.22
38	642	162[2/]	480	3.96
		Without Increase in Petroleum and Without Chrome Ore		
35	1,034	258[2/]	776	4.01
38	477	162[2/]	315	2.94

[1/] $1,000 rounded

[2/] To lower turning basin only (rough estimate)

Environmental Considerations

ALTERNATIVES TO CHANNEL DEEPENING

11. Various alternatives to channel deepening were considered for Charleston Harbor in the interim review of reports. These alternatives included an offshore terminal, a terminal at Cumming Point, pipeland from source and lightening. None of the alternatives proved to be a viable solution based on the needs of existing and prospective commerce, nor did they provide for future economic growth. The major environmental concerns for the modification of Charleston Harbor deal with the disposal of the dredged material, since the magnitude of the impact between the incremental deepening of the harbor and annual maintenance of the existing waterway is insignificant.

DISPOSAL AREAS

12. There are four different places in which dredged material can be disposed in the Charleston Harbor: alongside the channel; in the marsh; in upland areas; and, in the ocean. Environmental concerns have eliminated the first two methods from further consideration. This leaves upland disposal and ocean disposal. The upland disposal areas would temporarily destroy valuable farmland, wildlife habitat, woodlands and a variety of plants and bushes. Because of this detrimental effect on upland areas, and the fact that the bioassay and benthic studies reveal minimal effect from ocean dumping, it appears that ocean disposal would be the preferred method, depending on the availability of the required special equipment at the time the project is constructed.

Social Well-Being Considerations

13. Modification of Charleston Harbor will have favorable implications for the socio-economic well-being of state residents. On a state-wide basis, all would benefit from the transportation savings passed on to

consumers. In addition, the creation of new jobs to insure adequate employment for the projected future labor force in part depends on the continued growth of the port and related industries. The continued growth of the port will assist in maintaining the existing favorable distribution of population and economic activity between metropolitan complexes, small cities, and rural areas. There would be no detrimental effects on socio-economic well-being should the material be dumped in the ocean; however, upland disposal would probably destroy valuable farmlands, thus depriving the land owner of his livelihood. In addition, the seasonal workers who harvest the crops will also have to look elsewhere for employment.

Evaluation of Detailed Plan

SELECTED PLAN

14. The most desirable plan from an economic and environmental standpoint would provide for a channel depth of 42 feet in the entrance channel, 40-foot depths in the Cooper River channel, and 38 feet in Shipyard River. In addition to channel deepening, various channel and basin widening, as described in paragraph 2, is also included in the selected plan.

EVALUATION

15. The selected plan provides for sufficient depth and width to allow existing and prospective vessel traffic safe passage in the limits of the waterway. Moored vessels will have sufficient space to prevent protruding into the Federal project. The danger encountered at the northerly approach to the Cooper River Bridge will be reduced considerably due to the bend easing. The existing danger along tanker row (Filbin

Creek and North Charleston Reaches) to moored and passing vessels would be all but eliminated with the implementation of channel enlargement and realignment in this area. The additional turning basin sizes will allow the larger vessel which is now using or will use Charleston Harbor to turn more effectively and with greater safety. The implementation of this plan will allow Charleston to compete with other ports along the Atlantic coast. It will reduce the transportation costs considerably for the various commodities, thus providing lower costs for the consumer.

APPENDIX E

COMMENTS FROM OTHER AGENCIES

APPENDIX E

COMMENTS FROM OTHER AGENCIES

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The South Carolina Wildlife Federation

Arcadian Plaza, Suite B-1
4949 Two Notch Road • Columbia, South Carolina 29204
Phone (803) 786-6419

February 20, 1980

Maj. Gen. Joseph K. Bratton
510 Title Building
30 Pryor Street
Atlanta, Georgia 30303

Re: Navigational Channeling Operations in South Carolina

Dear Gen. Bratton:

The South Carolina Wildlife Federation has maintained as a primary interest the protection and enhancement of our coastal ecosystem. This letter is to acquaint you with our concern for the potential role that channel maintenance operations play with respect to these fragile balances.

The South Carolina Wildlife Federation (SCWF) is committed to a policy which assures that the inevitable negative influences and impacts of dredging operations are minimized to the maximum extent obtainable. Under this policy, we find it necessary to comment most forcibly on those aspects of the Phase I Charleston Harbor proposal[1] which do not insure that our goal of "minimum obtainable negative impact" is being met. While the specifics that follow refer to the Charleston project, the principles involved pertain equally to navigation and water development operations statewide.

Our first concern relates to the broad question of disposal of dredge material. Our organization is committed to the utilization of "ocean dumping" in every instance where Environmental Protection Agency guidelines permit. We are therefore encouraged, but not reassured, by the present Corps' position on this matter. We fail to detect a conscious commitment to ocean dumping "whenever EPA guidelines permit" - rather, we sense that ocean dumping has been tentatively embraced when "we can work it out". The SCWF maintains that the Corps must adopt an unequivocal commitment to ocean dumping as an immediate and essential first step. Such a commitment can then trigger the determination to "have in hand at the earliest date" the physical capability to employ the ocean dumping technique. In short, endorsement of the virtues of ocean dumping (ref.) does not assure its benefits are realized. Thus, we applaud the endorsement but fault the failure to insure the where-with-all.

Our second major concern is the insufficient sensitivity accorded the principle of natural resource/wildlife mitigation and compensation by the Charleston District. The SCWF takes specific exception to their position on compensation for the 10 acres of marsh to be lost to the Shipyard River channel. National objectives with regard to mitigation and compensation are clearly established. The marsh in question is a productive resource whose unavoidable loss must be effectively counterbalanced. However, despite this obvious relationship the District has taken a negative approach. Unfortunately, one can frequently predict the District's posture with regard to natural resource mitigation/compensation matters. Thus, their attempt (pg. 119 ref.) to characterize the need for compensation as "unrealistic" while regretable was not unexpected. The rationale for mitigation/compensation of the Shipyard channel marsh has been clearly established in the comments by the U. S. Fish and Wildlife Service within the report. The SCWF is committed to a policy of insuring mitigation/compensation for natural resource losses within the state. It is our position that the final plan must include compensation for the ten acres lost to the Shipyard channel if the project is to conform to national policy.

South Carolina's coast is a vital natural resource whose interests have not been sufficiently safeguarded in the past. As with all things, constructive change is preceded by the sure realization that we can do better. We ask that you consider avenues wherein improved safeguards can be assured and that you respond positively to the specific areas enumerated above.

Sincerely,

Sam Crouch
President

SC/pg
CC: National Wildlife Federation
Col. William W. Brown, Charleston District, U. S. Corps of Engineers

---

[1] Charleston Harbor Phase I AE & D Studies, Charleston District, Dec. 1979.

Response to South Carolina Wildlife Federation

Our records show that copies of the Draft and Final Environmental Impact Statements were mailed to the South Carolina Wildlife Federation in 1974 and 1976, but that no comments from the Wildlife Federation were received. The planning stages of this study were begun in the late 1960's, and the comments in your 20 February letter indicate that you are not aware of the developments leading up to the December 1979 Phase I report.

Ocean Disposal. Your characterization of the Charleston District's position on ocean dumping does not acknowledge the District's long-standing support and argument for this type of disposal. In 1968, as part of its long-range disposal study, the Charleston District first developed the concept of ocean disposal for all Charleston Harbor material. At this time, the District was alone in advocating ocean disposal. By letter of 29 November 1972 the U. S. Environmental Protection Agency directed that, "All sediment upstream from the harbor entrance on a line from Sullivans Island to Cummings Point should be disposed of on upland areas." (EPA has authority under P.L. 92-532 to designate or prohibit designation of ocean dump sites.) The South Carolina Department of Wildlife and Marine Resources by letter of 27 November 1974 stated, "In our opinion, upland disposal in selected diked areas would be far more desirable as well as safer than offshore disposal." The National Marine Fisheries Service also voiced reservations about ocean dumping.

It was through the District's original suggestion and persistence that the various environmental agencies and organizations eventually came to support the concept of ocean disposal for inner harbor material. In spite of the discouraging initial response to its suggestion, the Charleston District continued its studies to demonstrate the environmental acceptability of ocean dumping. A review of the Charleston Harbor Estuarine Values Study conducted under contract to the District in 1971 and 1972, convinced the U. S. Fish and Wildlife Service in 1974 that ocean disposal was the best method. In 1975 the District conducted sediment and elutriate analyses to

update the studies done in 1971, and to determine if inner harbor sediments were suitable for ocean disposal. By the time the final EIS was circulated, most agencies and groups favored or cautiously went along with ocean dumping. A Congressional moratorium on the development of any new dredge equipment by the Federal Government delayed any direct action by the Corps to acquire the new equipment. In 1978, the District entered into a $53,000 contract with the South Carolina Wildlife and Marine Resources Department to characterize the sediments of the ocean disposal area and to evaluate the effects of disposal on benthic inhabitants, considering possible alterations in substrate type, sediment chemistry, water quality, and direct physical changes. Also, in 1978, the Charleston District had conducted a $250,000 study, including bioassays, bioaccumulation assessments, sediment analyses and water quality work, which demonstrated that materials from the inner harbor and the entrance channel could be dumped in the ocean site in compliance with the Environmental Protection Agency's new regulations.

Given the above summary, the characterization of the District as reluctant or equivocal is inaccurate. The Charleston District must, however, be aware that its own commitment may not be shared by others: further changes in the positions of state or other Federal agencies could delay the implementation of ocean dumping by years; unforeseen economic or political conditions, such as the Congressional moratorium, could delay the commercial availability of the special equipment; a combination of factors, including dredge certification, could result in the District not receiving any bids to do the work (this has happened in the past). It now appears that ocean disposal can be carried out by 1985, the time of construction. Charleston Harbor is too important, however, to the economy of the state and to national defense, to state that no dredging will be done, if for some unforeseen reason, it cannot be dumped in ocean sites. Upland disposal remains a possibility that is proven and can be carried out, although with greater economic and environmental costs than ocean disposal.

Mitigation For Wetlands Near Shipyard River.

Prior to the development of plans to deepen and extend channels in Charleston Harbor, the Charleston District had the harbor's wetlands inventoried and assigned priorities according to their value for fish and wildlife and their other functions. This work was conducted by the South Carolina Wildlife and Marine Resources Department and was directed by an ad hoc committee chaired by the U. S. Fish and Wildlife Service as part of the early planning process. The purpose of this report was to avoid damage to wetland areas, particularly those that serve important functions. The wetland areas in Shipyard Creek were designated "priority IV:, the lowest category, and stated to have "little value to fisheries and wildlife resources".

The use of welands for navigation and anchorage is consistent with laws and national policies if (a) the proposed activity is necessary, (b) there is no alternate feasible site and (c) the wetlands are altered as little as possible. The proposed modifications to Shipyard River meet all three conditions. In addition, the quality is poor. Because of these factors, the Shipyard River marsh does not provide the same level of habitat as do similar wetlands, which are outside industrial areas. The concentration of pollutants by marsh plants and their ingestion by animals higher in the food chain might well be a negative factor, since most persistent chemicals are not removed from the estaurine system by marsh plants but are converted to a form that can more easily enter the food chain. It was recognized that the seven acres had some residual value, but, because of their low priority, no special mitigation measures were developed during the pre-1976 Feasibility Study.

During the Phase I Study which followed, the FWS was again funded by the Corps to review the project. Coordination and public hearings were conducted to determine if there were any changes or updating that were required. During the planning stages of Phase I there were no suggestions from FWS or any other agencies to retract earlier positions or to offer modifications in regard to Shipyard River. Mitigation was not suggested until the report preparation stage of the Phase I Study. At this late stage, it was not

possible to conduct the many evaluations necessary or to include additional land acquisition and other funding without greatly delaying the study. In order to comply with the 1965 Water Resources Planning Act, the National Environmental Policy Act, the Clean Water Act and the many other laws and Executive Orders that apply to a Federal project, the FWS's suggestions for mitigation will have to be developed in more detail, subjected to the many required evaluations (Section 404, 401 water quality certification, coastal zone management, etc.) and publicly aired through the various public meetings and notices. The land owners, U. S. Department of Agriculture, the U. S. Navy, the S. C. State Ports Authority and others who might object to the alterations of uplands must be given the opportunity to comment and offer alternate solutions. After a concrete plan is developed, fully analyzed and coordinated, the benefits, costs, and adverse impacts of the mitigation plan can be considered for inclusion in the Federal project.

The following issues must be addressed:

a. Value of existing wetlands. How important are the Shipyard River wetlands? How do they compare, for example, with wetlands in Bulls Bay, St. Helena Sound, or lesser developed areas in the Charleston estuarine system for food chain production, shellfish, nesting, spawning, recreation, endangered species, general habitat, maintenance of water quality, etc.? Why does the 1980 Fish and Wildlife Coordination Act report differ from the 1972 SCWMRD report and the FWS's 1974 recommendations on which the current plans were based?

b. Value of the open water habitat that would be created by widening of the turning basin. In the past, the FWS and the SCWMRD have discouraged the creation of wetlands in open water, citing the different but equally important functions of open water. The benefits of the new open water area would also be considered.

c. The existing and potential value of lands that would be cleared and graded for marsh building: for wildlife, endangered species, cultural resources, navigation, etc.

d. What would be done with the earth that would be excavated below the mean high water level? Would the excavation or disposal affect nearby marsh or water quality?

Once the impacts of both project actions and mitigation actions have been reassessed, the type and quantity of lands needed to offset the conversion of the Priority IV wetlands to open water can be determined. There are two areas where this might be done without having to mobilize a separate work force and array of equipment: (a) The high ground adjacent to the Shipyard basin might be excavated to create marsh of the same type and value as the existing marsh. This might be done under the same contract and at the same time as the widening of the turning basin. (b) A dragline working on an existing diked disposal area might convert seven acres of disposal area into marsh by moving the dike back. With the permission of the SPA and/or the Navy, this might be done without incurring land acquisition costs or significatnt adverse environmental impacts.

Since the marsh building was not suggested in the planning stages of Phase I, it could not be included in the Phase I report, but could be addressed in the planning stages of Phase II. The conversion of seven acres of disposal area to marsh could be accomplished as an alteration to dredging or diking methods, without going back to Congress for authorization or additional funds.

The South Carolina Wildlife Federation regards all dredging operations as having inevitable negative influences and has as its goal the "minimum obtainable negative impact". Although there are many projects where the impacts are adverse, disposal of dredged material can also, as in the case of Drum Island, create ideal insular habitat for birds or other wildlife. A suggestion by the Charleston District to create a park on the Bird Key end of Folly Island as part of its Folly River Navigation project was dropped due to total lack of support and the strong objections of local residents. Perhaps in the future, the South Carolina Wildlife Federation will join other agencies in seeking out situations where the project can result in a positive impact on natural resources.

South Carolina
Wildlife & Marine
Resources Department

James A Timmerman, Jr Ph.D
Executive Director

March 4, 1980

Colonel W. W. Brown
District Engineer
Corps of Engineers
P. O. Box 919
Charleston, S. C. 29402

Re: Charleston Harbor Improvement, Phase I Advance Engineering and Design Report

Dear Colonel Brown:

The following comments and recommendations are submitted by the South Carolina Wildlife and Marine Resources Department for consideration in further development of the design for "Deepening and Extending Channels for Navigation in Charleston Harbor, South Carolina".

The Phase I draft report indicates that offshore disposal of dredged material is planned for the existing open water or "Ocean Disposal Area" seaward of Morris Island and adjacent to the outer entrance channel. Currently, this site is receiving material removed from the harbor entrance channel by hopper dredge. In recent years, our Department has encouraged the use of open water disposal of dredged materials when condition and quantity of dredged sediments is known and meets standards producing minimum impact to acceptable receiving waters and bottoms. As indicated in two solicited reports ("A Study of the Charleston Harbor Estuary with Special Reference to Deposition of Dredged Sediments", 1972 and "Benthic and Sedimentologic Studies of the Charleston Harbor Ocean Disposal Area", 1979) submitted to the Corps of Engineers by the Marine Resources Division, the bottom within the designated offshore disposal site is generally sandy but supports a fairly rich and diverse community of invertebrate organisms. Both studies indicated that the bottom community appeared to suffer little from the addition of material deposited by the hopper dredge. However, the latter report goes on to state that:

> "On the other hand, the impact of dredged materials of a different particle size, such as silts from Charleston Harbor, would probably be significant if these sediments were not rapidly diluted and dispersed from the area by water currents.

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If such materials settled to the bottom of the disposal area, the impact would be detrimental to the types of organisms presently inhabiting the site."

To our knowledge, no investigation has been done to determine the fate of the deposition of fine grained dredged material in the Ocean Disposal Area.

One of our primary concerns would be potential seasonal impacts of migrating and spawning fish, shrimp and crabs. Although thorough sampling of the disposal area has yet to be done, areas immediately inshore are known to be heavily inhabited by spawning white shrimp each year during the period - April through June. Significant amounts of fine grained dredged materials introduced into the water column and settling on the bottom could impact recently spawned eggs, larval and post-larval animals unable to avoid these adverse conditions. Further investigations to determine the presence of spawning populations and larval and post-larval animals should be pursued.

Other concerns centering around open water disposal are directed to less specific impacts, but are nonetheless very important considerations that are recognized whenever this disposal method is used. These considerations have been touched upon in past reports (Vernberg, 1973), various Waterways Experiment Station Publications and other research (Hoss, et al., 1974) and include: impact of dredged sediments directly on organisms living in and on the bottom as well as in the water column; reintroduction into the water column of toxic materials contained in dredged sediments; and prediction of dredged material movement.

Although we have expressed concern about certain aspects of open water disposal, we are generally in favor of the technique when properly conducted. We, therefore, support and encourage the pursuit of plan 4, ocean disposal of all dredged material, with the condition that pending further more detailed study of the area around the inshore portion of the existing disposal site, the seaward expansion of the ocean disposal area be considered. A contingency plan should be adopted to modify or provide alternatives to the disposal scheme if more detailed studies or monitoring indicates the occurrence of adverse conditions. If plan 4 is not forthcoming and plan 3 is adopted, we request that Department representatives be included in further upland disposal site selection and consideration activities in the area around Daniel Island and any subsequent areas that might be considered.

Whereas the need for implementation of Plan 7, Shipyard River Deepening and Channel Expansion may be valid, the premise that the marsh system within Shipyard River is "unproductive" should be re-examined. Research conducted within the past few years indicates that marshes located in polluted environments can tend to absorb, break down or transform some toxic materials contained in the sediments and water column (Windom, 1977; Oviatt et al., 1977; Odum, H. T., 1977; Gardner, 1976). Although much research is needed to verify and expand these findings, to simply write-off altered and stressed marshes should not be condoned.

In 1972, this Department prepared a report, "A Study of the Charleston Harbor Estuary with Special Reference to Deposition of Dredged Sediments", under contract to the Charleston District for inclusion in the Charleston Harbor Study produced for the U. S. Fish and Wildlife Service. In that report, four priorities were subjectively determined to aid in the location of potential dredged material disposal sites. These priorities were set utilizing biological information available at that time. As pointed out earlier, research conducted since 1972 indicated that disturbed marshes can be of just as much or more value to estuarine ecosystems as pristine marshes. Additionally, a mid-February visit to Shipyard River by Department field biologists revealed substantial activity by wading birds and water fowl. The Wildlife and Marine Resources Department is concerned that marshes such as those in Shipyard River and other "priority IV" marshes in Charleston Harbor are being written off as wastelands. With research constantly producing new information on biological processes, the Corps of Engineers in its position of providing environmentally sound public works projects should be wary not to become complacent about applying the most recent data and technology when designing and constructing navigation projects. We continue to feel that where destruction or alteration of any wetland, whether previously disturbed or not, is proposed that some form of mitigation be adopted. The Department strongly supports such a concept in the case of the expansion of the Shipyard River channel and turning basin and looks forward to further investigation of possible mitigating alternatives while ensuring design integrity.

Sincerely,

James A. Timmerman, Jr.
Executive Director

JATjr/sa
cc: Elmer Whitten
Bearden
F&WS
NMFS

Response to South Carolina Wildlife
and Marine Resources Department

1. Ocean disposal.

a. See the response to the South Carolina Wildlife Federation on page E-3 of this Appendix.

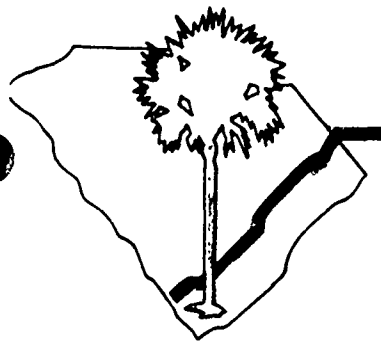
b. The quotation from the 1979 "Benthic and Sedimentologic Studies" conducted by SCWMRD under contract to the Charleston District states that there would probably be significant impact on the sediment type and benthic organisms if the inner harbor sediments settled to the bottom and were not rapidly dispersed. Both the 1972 SCWMRD report (page 88) and the 1979 report (pages 43, 45 and 48) indicate that even the heavier, larger grained sediments are rapidly dispersed. The finer silts would be suspended and moved even easier. Note also that the 1979 SCWMRD report does not state or imply that the change, if it should occur, would be adverse. The 1972 SCWMRD report says that a build-up of mud or silt "could result in the enhancement of adjacent areas by creating habitat for valuable species such as Penaeid shrimp. This, in turn, would generate potential for increased or, at least, more productive commercial fisheries." The 1979 report did state that the sandy disposal area was fairly rich and diverse, but only in comparison to the other sandy, relatively barren ocean bottoms along the Atlantic Coast. A close examination of the species shows that there are no live bottom areas and that the unexpected diversity and densities are due mostly to very small polychaete worms. The 1972 SCWMRD report described the present disposal site as "well-chosen on the basis of negligible disturbance to local fisheries, minimal build-up of sediments and adequate area within the dumping site for additional material."

c. As discussed in the Phase I report and the response to the S. C. Wildlife Federation letter, the dredged sediments have been tested and found to be acceptable for ocean disposal, in accordance with the latest bioassay and other techniques required by the Environmental Protection Agency. Further

studies by the Corps and EPA on the probable direction and rate of dispersion of fine materials will continue, and monitoring of the disposal operation will determine more exactly the beneficial and adverse effects of ocean dumping inner harbor material.

2. Shipyard River Turning Basin and affected wetlands. See the response to the S. C. Wildlife Federation on page E5 of this Appendix. The words "unproductive" or "wastelands" were not used by the Corps in its Phase I report to describe Shipyard River wetlands. Instead, the Corps used the SCWMRD's own phrases in describing the area: "little value to fisheries and wildlife resources", "significantly altered by development", "unrealistic to manage", and "fouled by industrial or other wastes". The Corps has not been complacent in reviewing new research or in the consideration of new alternatives; it has reviewed the literature, requested input from many sources, and has funded studies where the existing data was inadequate. However, it is pertinent to note that the low quality attributed by the Corps to the marsh in Shipyard Yard River represents the "site specific" findings of the SCWMRD. Furthermore, the SCWMRD gave no indication it wished to modify its published assessment of the quality of these marshes until its 4 March 1980 letter. Most reviewers would probably have considered it presumptuous on the part of the Corps to disregard the "site-specific" findings of the SCWMRD, an expert agency, on the basis of research conducted in other parts of the country under different conditions and circumstances. If, however, a person or agency wishes to alter its previous stance on an issue during the final stages of planning or to introduce a change which can not be explained in terms of the existing studies, this request for change must be by site-specific information which supports the proposed change.

As stated on page 116 of the Phase I report, the Corps can build marsh of comparable value to the seven acres of Priority IV wetlands as an integral part of project construction.



South Carolina Coastal Council

James M. Waddell, Jr.
Chairman

H. Wayne Beam, Ph.D
Executive Director

February 8, 1980

Colonel William W. Brown
District B
Department of the Army
Charleston District Corps of Engineers
P. O. Box 919
Charleston, SC 29402

Dear Colonel Brown:

The Draft Consistency Determinations in the Draft Report "Phase I, Charleston Harbor South Carolina Deepening and Extending Channels for Navigation" has been reviewed by the S. C. Coastal Council staff. We appreciate this opportunity to see how the consistency process may be best implemented for all concerned. Additionally, this early contact enables maximum use of staff resources to analyze this proposal and to seek further coordination between our agencies if necessary.

As Phase I is a study exploring alternatives for fulfilling the need to deepen and extend channels for navigation, the Council's response will be in the form of a discussion of the relative consistency of the alternatives. Future phases of the project proposal will be reviewed as developed. It is hoped our discussions at this phase will aid you in including decisions consistent with the S. C. Coastal Management Program in future phases.

Of greatest concern to the Council is the disposal of dredged material from the project. The Phase I study identifies five (5) upland sites on Daniel Island and strongly suggests that the ocean dumping alternative will be used if equipment and an EPA disposal site are available. It is noted, however, that the final selection of the method of channel construction will not be made until the problems associated with ocean dumping are resolved (p. 46 of Draft Report). Further, it is understood that the recommended plan for the project assumes upland site disposal because of the lack of certainty surrounding the ocean dumping alternative. Since upland disposal is recommended in the Phase I Draft Report, the Council would agree with the statement of consistency in the Draft Report (p. 114). Further, the Council would recommend that sites (D) and (E) be chosen as disposal sites over the other sites. This recommendation is based on Policy VIII B. 1.(e), p. III-57, S. C. Coastal Management Program (FEIS).

1116 Bankers Trust Tower • Columbia, South Carolina 29201 • (803) 758-8442

The ocean dumping alternative is of some concern to the Council. It is felt that information on the effects of this alternative is currently insufficient. Effects on the shrimping industry, other commercial fisheries, and the recreational fishing industry are considered to be issues requiring further study before this method is chosen.

As a final recommendation the Council urges the Corps of Engineers to consider creating marsh habitat equal in acreage to that which will be lost in the Shipyard River turning basin portion of the project. The U. S. Fish and Wildlife Service would be able to help you in this regard.

Thank you for working with the Council to develop mutually agreeable procedures to implement our respective federal consistency responsibilities. If elaboration of these comments is necessary please do not hesitate to contact me to arrange a meeting. I look forward to working with you and your staff as future phases of the project are planned.

Sincerely,

H. Wayne Beam

H. Wayne Beam
Executive Director

HWB/jkw

cc: Senator James M. Waddell
Mr. Duncan C. Newkirk
Mr. Elmer Whitten

Response to Comments of the South Carolina Coastal Council

See the response to the South Carolina Wildlife Federation beginning on page E-5 of this Appendix in regard to Shipyard River, and in regard to the number of studies and tests that have been conducted thus far to demonstrate that dredged material can be dumped at the ocean site in compliance with EPA regulations and without significant adverse effects on marine organisms or water quality. The bioassays and chemical evaluations indicate that after a short time for mixing, the levels of dissolved and suspended components will not exceed the limiting permissible concentrations. Because the chemical constituents of the dredged material appear to be safe for ocean disposal, the most recent work in the disposal area has emphasized the possible physical impacts on substrate and the less mobile invertebrates. The two studies (1972 and 1978) by the SCWMRD indicate that dispersal of even the heavier grained material appears to be quite rapid. The 1972 SCWMRD "Study of the Charleston Harbor Estuary with Special Reference to Deposition of Dredged Sediments" stated that an increase in soft muds or silts could enhance adjacent areas by creating habitat for valuable species such as Penaeid shrimp and generating more productive commercial fisheries." The Charleston District may conduct one additional study to predict, in general terms, the direction and rates of movement of the various components of the material; however, most agencies have agreed that a close monitoring of the initial disposal from the inner harbor would provide the best information on the overall effects. Having analyzed the sediments and benthic communities in 1978, we have a baseline to which we can compare the conditions after inner harbor disposal.

South Carolina Department of Archives and History
1430 Senate Street
Columbia, S. C.

P. O. Box 11,669
Capitol Station 29211
803 — 758-5816

February 11, 1980

Colonel William W. Brown
District Engineer, Corps of Engineers
Department of the Army
Charleston District, P.O. Box 919
Charleston, S.C. 29402

Re: Phase I Report, Charleston Harbor

Dear Colonel Brown:

This is written in response to your request for our comments on the draft Phase I Advance Engineering and Design Report on Charleston Harbor.

It is noted that if upland sites, rather than ocean sites, are chosen for the disposal of dredged material in the later stages, an intensive survey will be conducted to locate and evaluate sites that may be potentially eligible for inclusion in the National Register.

We expect the Army Corps to provide us with the report of this survey once the final disposal areas are selected, so that the compliance procedures outlined in 36CFR800 can be completed, and we can provide formal comment as described by Section 106 of the National Historic Preservation Act of 1966, as amended.

The Federal procedures for the protection of historic properties (36CFR800) require that the Federal agency official in charge of a federally funded or licensed project consult with the appropriate State Historic Preservation Officer. The procedures do not relieve the Federal agency official of the final responsibility for reaching an opinion of his own as to whether or not historic values have been adequately taken into account in allowing the project to proceed. The opinion of the State Historic Preservation Officer is not definitive, either by law or by established Federal procedure. In reaching a conclusion of his own, the Federal agency official may well wish to consult other experts.

Sincerely,

Charles E. Lee
State Historic Preservation Officer

CEL/dkn
cc: Mr. David Chamberlain
Berkeley-Charleston-Dorchester
Council of Governments

Response to the South Carolina
State Historic Preservation Officer

The SHPO will be provided a copy of the intensive survey, should it be necessary to acquire new disposal areas, and his opinions will be sought in regard to the importance and management of resources present.

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Room 279, Federal Building
Asheville, North Carolina

March 3, 1980

Colonel William W. Brown
District Engineer
U.S. Army Corps of Engineers
P.O. Box 919
Charleston, S.C. 29402

Dear Colonel Brown:

This letter is in regards to the Corps of Engineers ongoing Phase I study to determine the advisability of modifying the existing Charleston Harbor Navigation Project, South Carolina. The Phase I study was authorized by the Water Resource Development Act of 1976 (Public Law 94-587). The Service's letter report is provided in partial fulfillment of Section 2(b) of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.). Our report, which is to accompany the Corps Phase I GDM Report to higher authority, has been reviewed by the South Carolina Wildlife and Marine Resources Department (SCWMRD) and the National Marine Fisheries Service (NMFS). The endorsement of our report, specifically the recommendations, by these agencies is provided by letter dated September 7, 1979, from Dr. James A. Timmerman, Jr., Director SCWMRD, and by letter dated August 23, 1979, from Mr. William H. Stevenson, Regional Director, NMFS. A copy of each letter is appended. The Service's responses to the Corps of Engineers comments on the preliminary draft FWCA report are contained in Attachment 1.

DESCRIPTION OF PROJECT AREA

The federally authorized project is located in Charleston Harbor, a natural harbor, formed by the confluence of the Ashley, Cooper and Wando rivers, (Figure 1). The Harbor lies approximately midway of South Carolina's Atlantic coast and is flanked by the City of Charleston on the western shore; James Island, a residential community, and Morris Island, a barrier island used as a spoil disposal area, on the south; the community of Mount Pleasant and Sullivan's Island, a developed barrier island, on the north; and the Atlantic Ocean on the east.

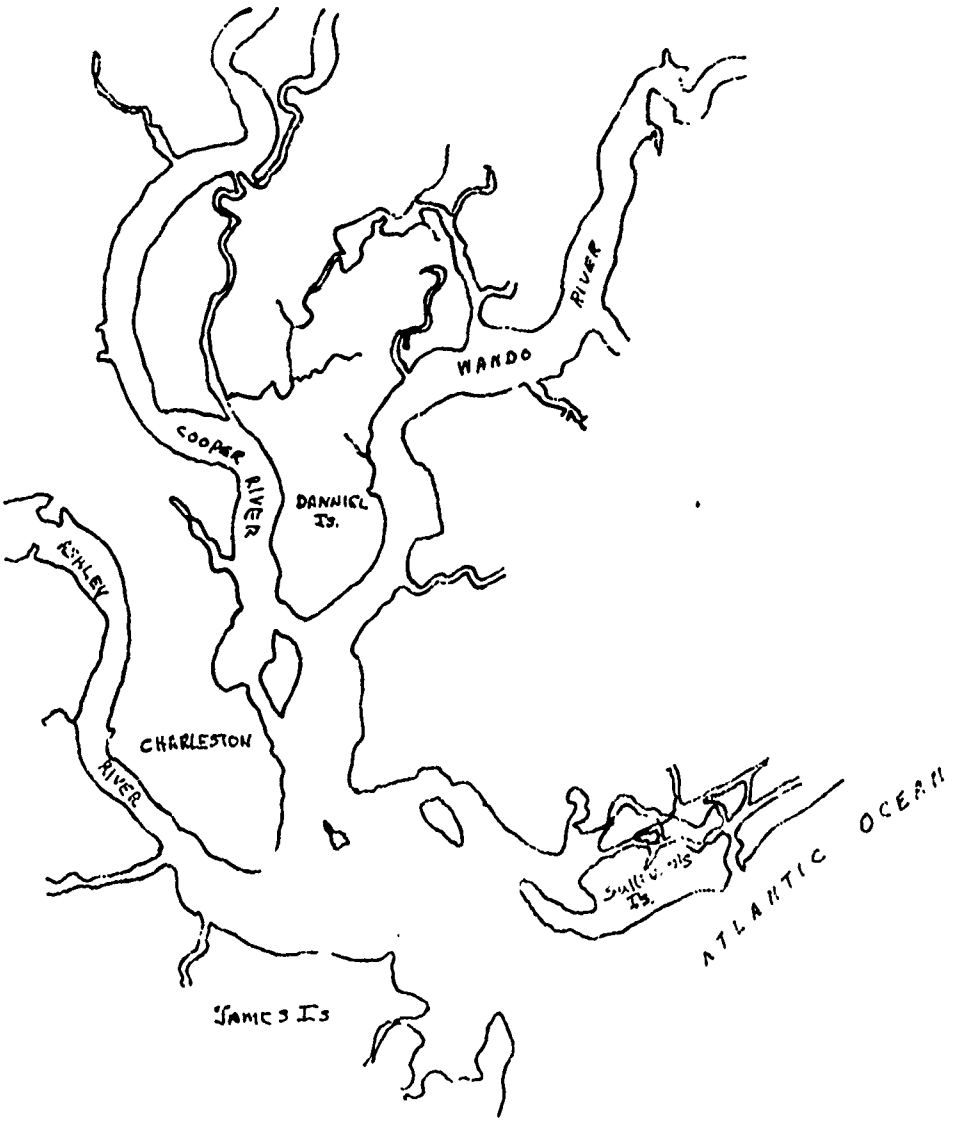


Figure 1. Charleston Harbor, South Carolina

The Harbor is approximately 14 square miles and has natural depths of up to 25 feet at MLW. The substrate is composed predominantly of very fine sand in shallow water (10 feet) and silt and clay in deeper areas. An average tidal range of over 5 feet has contributed to the development of a fringe of regularly flooded marsh around a large portion of the Harbor. Marsh areas of up to one mile in width occur between Sullivan's Island and Morris Island and the adjoining mainland. Salt marsh vegetation is composed predominantly of smooth cordgrass (Spartina alterniflora) and black needlerush (Juncus roemerianus). Brackish marsh vegetation found primarily on the Cooper River above river mile 16 is composed of various bulrushes (Scirpus sp.), cattail (Typha sp.) and giant cordgrass (S. cynosuroides). The Harbor contains approximately 5,200 acres of regularly flooded marsh, the Wando 6,400 acres, the Ashley 4,300 acres and the Cooper 9,200 acres. Due in part to the turbid conditions of the waters, the Harbor does not contain any substantial acreage of submergent vegetation with the exception of some algal growth. However, the associated rivers, especially Cooper River, have notable infestations of Brazilian elodea (Egeria densa). The majority of primary production in the Harbor takes place in the fringing salt marshes. Nutrient inputs from these marshes and the river systems feed the Harbor's detrital based food web.

The Harbor is a stratified or salt-wedge type estuary with salt water intrusion being a function of the amount of water released through the Pinopolis Dam on the Cooper River and the corresponding tide sequence or range. The Cooper River, as a result of a 1944 diversion project, presently carries most of the Santee River Basin flow and provides the majority of the freshwater inflow into the Harbor. The Wando and the Ashley rivers originate within the coastal plains region, as once did the Cooper River, and consequently provide minor freshwater inflow.

The majority of upland areas around Charleston Harbor contain either residential or commercial development. Daniel Island, which extends northward from the confluence of the Cooper and Wando rivers, supports agricultural activities and a diversity of wildlife habitats. The majority of the remaining undeveloped upland areas around the Harbor were formerly wetlands which are presently serving as dredged material disposal areas. It is estimated that within the Harbor approximately 6,300 acres of regularly flooded marsh have been lost due to spoil disposal practices, while approximately 100 acres have been created as a result of past open water disposal practices.

The existing federally authorized project within Charleston Harbor provides, in part, for a 35-foot deep navigation channel of varying width from the Atlantic Ocean through Charleston Harbor and up the Cooper River. The overall length of the channel is nearly 22 miles. A spur channel extends approximately two miles up the Shipyard River, formerly a small tidal stream, to commercial docking facilities.

An average of approximately 5 million cubic yards of material is removed annually from the inner harbor channels to maintain the existing federal project. The entrance channel is maintained with a hopper dredge and the material is placed in an ocean disposal site. The remaining channels are maintained with hydraulic pipeline dredges and the material is placed in five existing diked disposal areas (Figure 2). The disposal areas or their easements cover a total area of almost 3,500 acres and are located near the major shoal areas. The Morris Island disposal area, located near the mouth of the Harbor, receives the material dredged from the anchorage basin and lower harbor which equals approximately 1.5 million cubic yards annually. The Corps estimated in 1975 that the site could retain an additional 28 million cubic yards.

One of the disposal areas which receives dredged material from the upper harbor channels is located on the southern tip of Daniel Island. The approximately 700-acre site receives an average of 2.3 million cubic yards of material annually. In 1975, the area was being filled at a rate of 1.6 feet per year and was anticipated to reach its maximum capacity (22' MLW) sometime in the early 1980's. However, in 1979, the Corps anticipated the continual use of the area for the next 10 years.

The 200-acre Drum Island disposal area is located south of Daniel Island. The area receives approximately 500,000 cubic yards of material annually from the lower harbor. The Corps, in 1979, estimated that at its present rate of use the area would last another six to eight years if the project sponsor was successful in extending the existing disposal easement. The 817 acre Clouter Creek disposal area located on the east side of the Cooper River receives about 700,000 cubic yards annually. This site receives material from the upper harbor and periodically from Shipyard River and will retain material for an additional 25 years at the present rate.

PLAN OF DEVELOPMENT

The proposed project consists of deepening and widening the existing main navigation channels for Charleston Harbor including Shipyard River. The channels and turning and anchorage basins would be deepened to a depth of 40' MLW and widened as necessary. The various plans (alternatives) evaluated in the Phase I study differed in channel depths and spoil disposal options. The plan which the Corps will recommend for construction and the one evaluated in this report consists of:

a. Deepening the existing entrance channel from a depth of 35 feet to a depth of 42 feet. The channel width will not be changed from its present 1,000 feet. This reach extends from Mile 0.6 seaward to the 42-foot contour, a distance of approximately 11.8 miles.

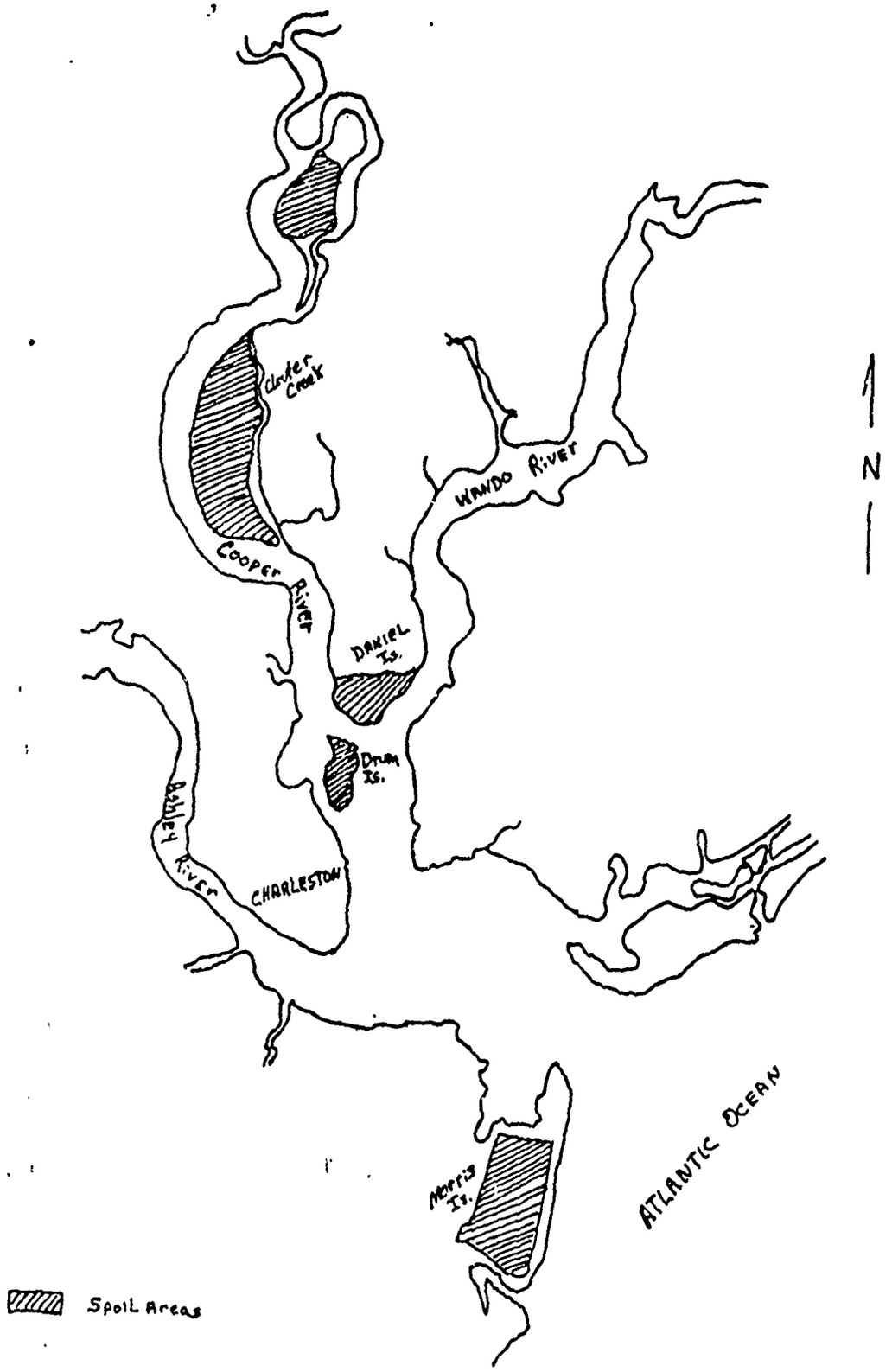


Figure 2: Existing Dredge Material Disposal Sites, Charleston Harbor

b. Deepening the existing harbor channels from a depth of 35 feet to a depth of 40 feet from the Entrance Channel (Mile 0.6) to Mile 15.7 at Goose Creek. Widths will be variable because of minor alignment changes and easing of bends.

c. Deepening of the Shipyard River channel from 30 feet to 38 feet. In addition, the alignment of the upstream and downstream turning basins and connector channel will be shifted in a northeasterly direction to provide a 125 foot buffer zone between the channel edge and existing piers on the south side of the river. The realigned turning basins will be enlarged to accomodate a turning diameter of 1000 feet and the connector channel between them will be widened to 250 feet. The width of the Entrance Channel will not be changed.

d. Enlargement of the anchorage basin at the Harbor mouth. The basin will be deepened to 40 feet and the south side will be extended 1,400 feet.

e. Enlargement of the existing turning basin at the head of the commercial channel.

f. Enlargement of an existing turning basin adjacent to the Columbus Street docks.

g. Shifting of channels near the various terminals to provide 125 feet between existing piers and the edge of the channel.

Constructing the recommended improvements would result in the removal of nearly 28 million cubic yards of material. Approximately 12 million cubic yards of predominantly sandy material would be removed from the Entrance Channel and placed in an ocean disposal site. The remaining material would either be disposed of at sea through the use of specially designed dredging equipment, if available, or in diked upland disposal areas. If dike areas are used, about 3.7 million cubic yards would be placed in the existing Clouter Creek disposal area. Disposal of the remaining 11.3 million cubic yards would require a new 1,000 acre site. For planning purposes, five potential upland sites totalling 2,600 acres on and north of Daniel Island were identified (Figure 3). Sites D and E have been tentatively selected to receive the construction material Maintenance of the improved channels would result in an estimated 20 percent increase in the volume of material dredged annually. Presently, the project plans indicate that maintenance material would not be placed in the new disposal sites but would be disposed of in the existing disposal areas. However, the existing Daniel Island disposal site is anticipated to reach its capacity around 1989. Dredged material normally placed in this site will be placed in some other site that is within an economical pumping distance. The 1,000 acre disposal site developed as a result of the deepening project would be within an acceptable pumping distance and therefore a likely choice to receive maintenance material.

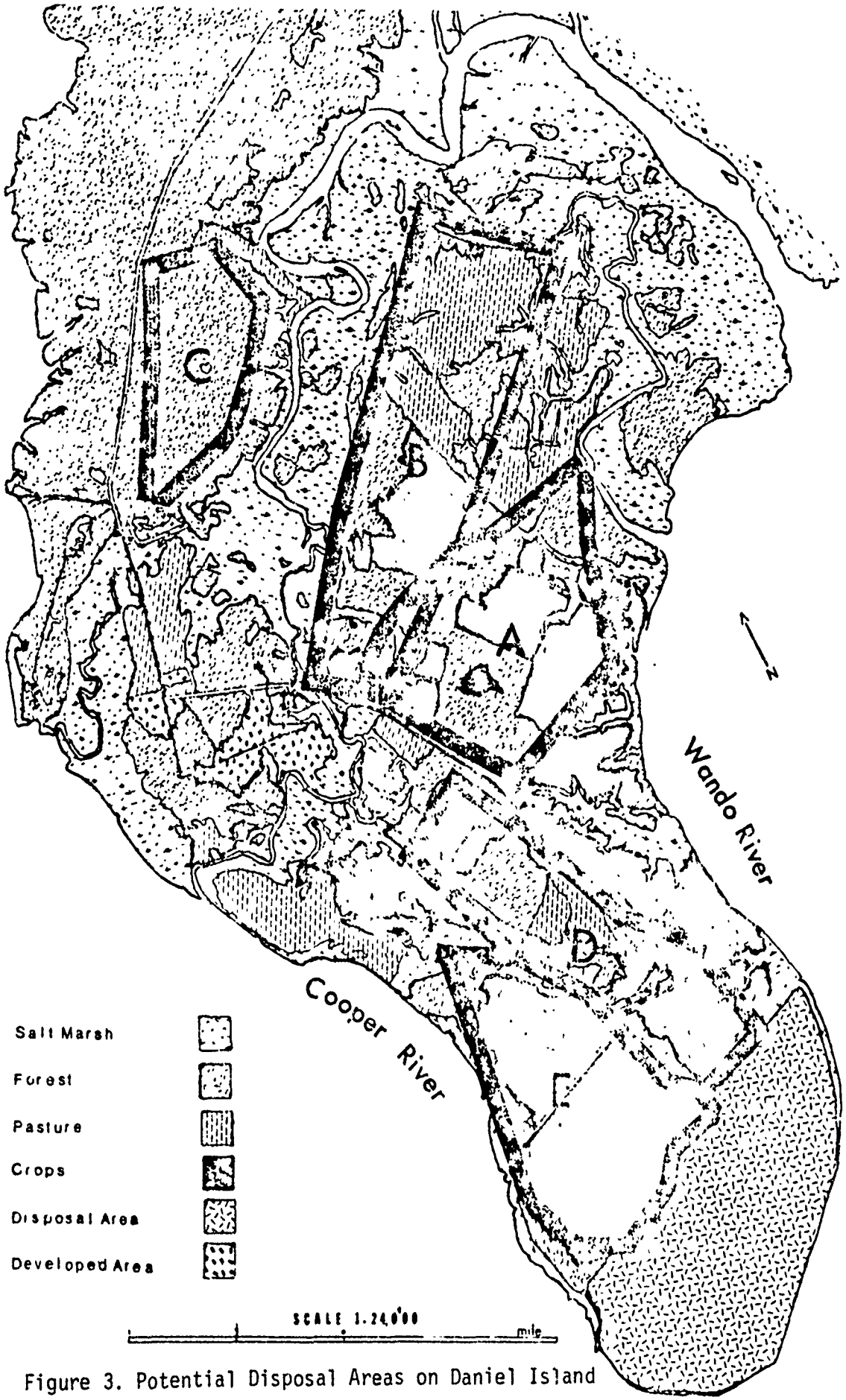


Figure 3. Potential Disposal Areas on Daniel Island

FISHERY RESOURCES

Without Project

Fishery resources within Charleston Harbor and the project area consist of numerous estuarine and marine species. Demersal fish species which are typically associated with the lower water column and substrate of Charleston Harbor include star drum (Stellifer lanceolatus), croaker (Micropogon undulatus), bay anchovy (Anchoa mitchilli), Atlantic menhaden (Brevoortia tyrannus), spotted hake (Urophycis regius), weakfish (Cynoscion regalis), spot (Leiostomus xanthurus), blueback herring (Alosa aestivalis), white catfish (Ictalurus catus), and silver perch (Bairdiella chrysura) (Shealy et al. 1974). Other fish species which are of commercial or recreational value and are commonly found within Charleston Harbor include flounder (Paralichthys spp.), redfish (Sciaenops ocellata), spotted seatrout (Cynoscion nebulosus), bluefish (Pomatomus saltatrix), black drum (Pogonias cromis) and striped mullet (Mugil cephalus).

Four anadromous fish species, American shad (Alosa sapidissima), blueback herring (Alosa aestivalis), hickory shad (Alosa mediocris), and striped bass (Morone saxatilis), and one catadromous species, American eel (Anguilla rostrata) utilize Charleston Harbor and its tributaries as migration routes and spawning areas. The shortnose sturgeon (Acipenser brevirostrum), an endangered species, has recently been documented as occurring within Charleston Harbor.

Turner and Johnson (1974) found that within the low salinity (0.0 $^{o}/_{oo}$-3.0 $^{o}/_{oo}$) tidal creeks of the Cooper River the most abundant fish species were Atlantic croaker, mummichog (Fundulus heteroclitus), menhaden, and spot. Other common species included tidewater silverside (Menidia beryllina), silver perch, striped mullet, goby (Gobionellus shufeldti) and southern flounder. Common invertebrates included hardback shrimp (Palaemonetes spp.), penaeid shrimp, blue crab (Callinectes sapidus), and squid (Loliguncula brevis).

Fishes which commonly reside within the intertidal marshes of the project area include mummichog, sheepshead minnow (Cyprinodon variegatus), Atlantic silverside (Menidia menidia), and bay anchovy. Other species which frequent intertidal marshes include both species of mullet and several species of Sciaenids. Tidal pools in the high marsh areas are inhabited by species such as sailfin molly (Poecilia latipinna) and mosquitofish (Gambusia affinis).

The project area does not support harvestable oyster or clam resources. However, oyster reefs do occur throughout the project area. The Wando River contains an estimated 390 acres of valuable seed oysters. Oysters are removed from these reefs and placed on reefs throughout the coastal area to replenish the stock. Other reefs throughout Charleston Harbor

and the Cooper and Ashley rivers are closed to commercial or recreational harvest due to pollution. Major clam beds have not been found within the project area.

Charleston Harbor estuary serves as a valuable nursery for Penaeid shrimp. Studies have shown that the Cooper River - Charleston Harbor estuary is intensively utilized by white and brown shrimp. In a statewide trawl survey, Bishop and Shealy (1977) found that Charleston Harbor estuary produced a mean catch over twice that of areas south of Charleston Harbor and nearly four times the catch from areas north of the Harbor. Nearly 58% of the total white shrimp and 10% of the brown shrimp collected came from three Charleston Harbor stations. When comparing the Cooper River catches with the next most productive area, the North Edisto River, nearly twice as many shrimp by numbers were caught in the Cooper River. In an effort to explain the difference in their catch data, the authors concluded that the differences probably result from several direct and indirect complex reactions with perhaps freshwater inflow being one of the key elements.

The future condition of the existing aquatic resources within the project area is obscured by the implementation of the Cooper River Rediversion Project. The rediversion project will reduce the freshwater inflow into Charleston Harbor by 80 percent. The resulting impacts on the aquatic resources will be both adverse and beneficial. The final overall impact continues to be a controversial subject. However, it can be safely stated that the existing aquatic resources will be significantly altered as a result of the project. Due to cumulative impacts of other human induced alterations, resulting from commercial, industrial and residential developments, it is anticipated that the fishery resources within the project area will experience a gradual decline over the next 50 years.

With the Project

Deepening and widening the channels and basins within Charleston Harbor would destroy the invertebrate populations which inhabit the channels and are unable to avoid the suction dredge. Studies have generally shown that populations partially recover within a few months and reach pre-project conditions within twelve to eighteen months. The project would also convert an additional 75 acres of previously undisturbed bay bottom to channels and basins. The benthic populations inhabiting these areas would not be expected to return to pre-project conditions due to changes in depth, and substrate composition as well as frequency of disturbance from maintenance operations. However, the populations would be similar to those inhabiting other project channels and basins. This expected change in population structure would not have a detectable affect on the Charleston Harbor fishery resources.

Deepening the project channels would also increase the extent of the salt wedge up the Cooper River. The wedge will progress even further upstream when the Cooper River Rediversion Project is implemented. The impacts of this encroachment on upstream brackish and freshwater resources cannot be fully evaluated at this time. However, fishery resources within the Cooper River will be impacted.

Widening of the Shipyard River channel and turning basins would destroy an estimated 10 acres of tidal salt marsh. The marsh receives daily tidal inundation and is vegetated with smooth cordgrass (Spartina alterniflora) and scattered black needlerush (Juncus roemerianus). The area serves as a nursery and escape area for juvenile forms of fish and shellfish and as a feeding area for numerous fish and wildlife species. Two wildlife species observed feeding in or adjacent to the Shipyard River marsh have been the great egret and osprey.

The disposal of non-polluted construction and future maintenance materials in an approved ocean dumping site would destroy those aquatic resources that are incapable of avoiding the dumping operation. The construction and future mainentance material dredged from the inner harbor will be of a different particle size than the sediments of the disposal site. Consequently, disposal of inner harbor material may alter the existing benthic population of the disposal site. The extent of this alteration and its adverse or beneficial affects are unknown. The placement of dredged material within diked upland sites should not have any long-term adverse impacts on aquatic resources provided that discharge outlets are properly located and adequate buffers are maintained between diked upland areas and wetland habitats.

WILDLIFE RESOURCES

Due to the nature of the project, wildlife resources would be impacted only as a result of dredge material disposal and secondary development spurred by the project. Consequently, the major portion of this section will discuss those resources associated with Daniel Island where potential disposal sites have been identified.

Without Project

Daniel Island represents the only remaining large acreage of undeveloped high ground within the immediate project area. It is located at the junction of the Wando and Cooper rivers (Figure 1). The island is owned by the Guggenheim Foundation and contains an estimated

6,200 acres of which approximately 2,200 acres are tidal salt marsh. Presently, the island is used primarily for farming purposes; however, nearly 700 acres are committed to a diked spoil disposal area. The remaining acreage is a mixture of cropland, pasture and woodlots (Figure 4). Principle crops grown on the island include soybeans, corn, tomatoes, and cucumbers. Commercial quantities of each crop are grown and transported to market each year.

The woodlots scattered throughout the island vary in size from 10 acres to over 100 acres. The predominant overstory vegetation found in the woodlots consists of hardwood species, such as water oak, live oak, hickory, sweetgum and blackgum. However, loblolly pine is dispersed throughout most of the woodlots. Understory vegetation is dominated by elderberry, wax myrtle, smilax, vaccinium, American beauty berry, chain fern and various grasses.

Year-round residents on the island consist of two households. During crop harvesting periods numerous migrant workers are provided temporary quarters on the island. Some of the typical wildlife resources inhabiting the island are listed in Table 1.

Daniel Island is comprised of a diversity of habitats which are utilized by a large array of wildlife species. For example, prime range for bobwhite quail consists of a mixture of woodland, scrubs, grassland, and cultivated land, each of which is appropriately dispersed throughout Daniel Island. Similarly, the interspersion of habitats on Daniel Island provide good range for wild turkey and white-tailed deer. Studies have also shown that the interspersion of forest, crops, and pasture similar to that on the island provides prime habitat for an extremely large number of non-game bird species.

Wildlife population studies have not been performed on the island. However, personal communication with state biologists and Mr. J.O. Murray, manager of the Daniel Island property, provided the following information regarding population estimates of the major game species. The deer herd is estimated at between 200 and 300 deer. Observations of wild turkeys indicate that the island supports one of the highest populations within the coastal area. The squirrel, quail and dove populations are considered high. During winter migration periods, numerous waterfowl also utilize the island.

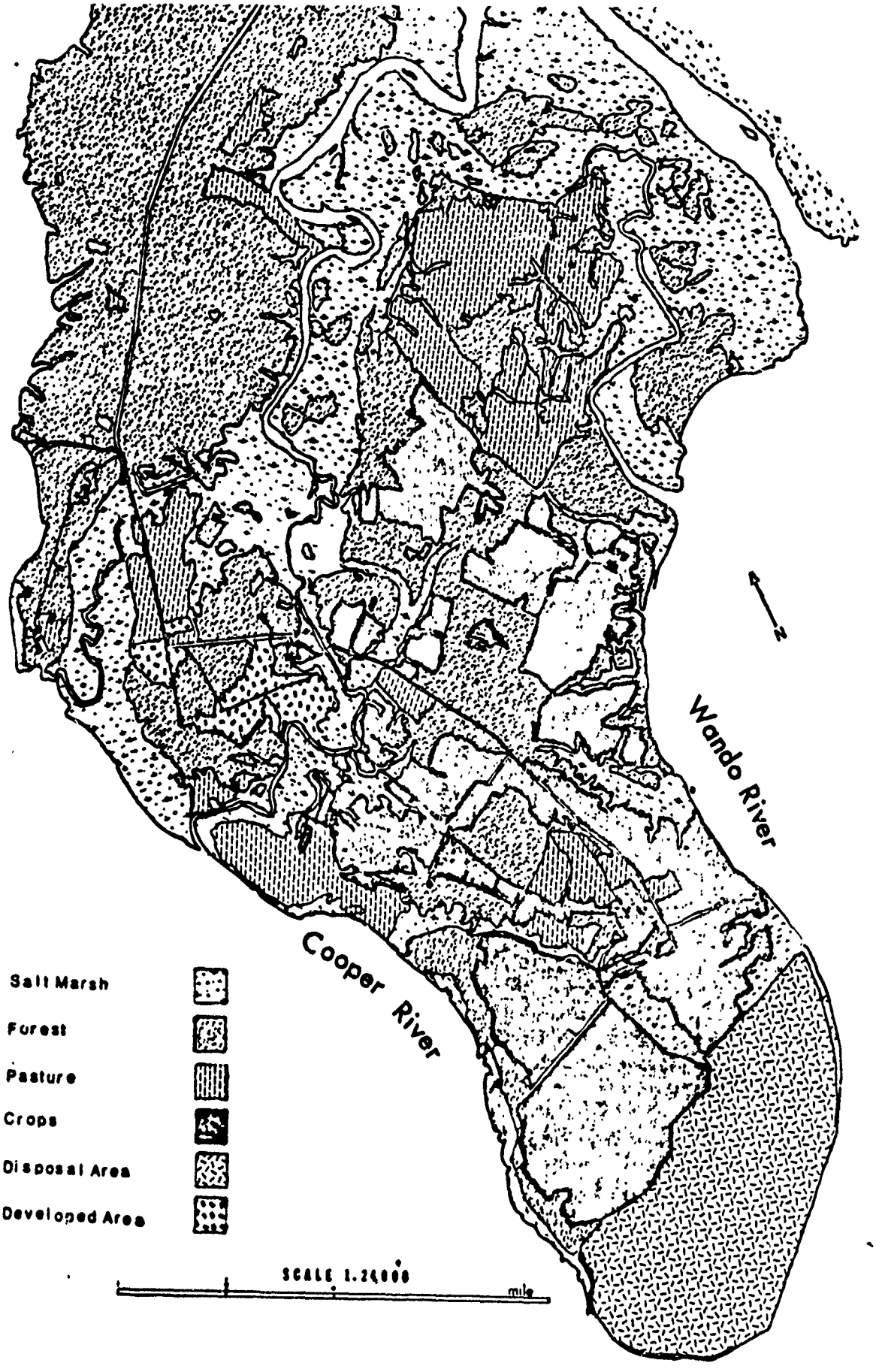


Figure 4. The Distribution of Vegetative Communities on Daniel Island.

Table 1. Some typical wildlife species expected to inhabit Daniel Island.

Amphibians and Reptiles	
Southern toad	(*Bufo terrestris*)
Southern fence lizard	(*Sceloporus u. undulatus*)
Five-lined skink	(*Eumeces inexpectatus*)
Corn snake	(*Elaphe g. gutatta*)
Yellow rat snake	(*E. obsoleta guadrivittata*)
Southern blackracer	(*Coluber constrictor priapus*)
Eastern kingsnake	(*Lampropeltis g. getulus*)
Birds	
Eastern bobwhite	(*Colinus virginianus*)
Meadowlark	(*Sturnella minor*)
Carolina wren	(*Thryothorus ludovicians*)
Mourning dove	(*Zenaidura macroura*)
White-throated sparrow	(*Zonotrichia albicollis*)
Southern crow	(*Corvus brachyrhynchos paulus*)
Wild turkey	(*Meleagris gallopavo*)
Eastern red-tailed hawk	(*Buteo jamaicensis borealis*)
Southern screech owl	(*Otus asio asio*)
Mammals	
Harvest mouse	(*Reithrodontomys humulis*)
Eastern woodrat	(*Neotoma folridana floridana*)
Virginia oppossum	(*Didelphis virginiana*)
Raccoon	(*Procyon lotor*)
Gray squirrel	(*Sciurus carolinensis*)
Fox squirrel	(*Sciurus niger*)
White-tailed deer	(*Odocoileus virginianus virginianus*)

The Mark Clark Expressway, a federally assisted project which is expected to begin in 1986 and be completed around 1990, will cross Daniel Island (Figure 5). The highway will bisect the northwestern portion of the island and result in the commitment of approximately 32 acres to right-of-ways. The construction activities, future use of the highway, lands committed to right-of-ways, and improved access to Daniel Island are expected to cause a reduction in existing wildlife populations. The wild turkey population on the island would be the most adversely impacted. Studies indicate that the turkey population could not tolerate the excessive human activities that will be associated with highway construction and future use.

It is anticipated that changes in the present land use practices will commence soon after the completion of the expressway (1990). Consequently, other populations of wildlife resources, such as white-tailed deer and bobwhite quail will start to gradually decline. Without the Charleston Harbor Project and without the continued growth of the port, Daniel Island would experience primarily residential and commercial type development. It is estimated that reduced populations of the existing wildlife resources would continue to inhabit the island for the next 40 to 50 years.

With the Project

The proposed project would have direct and temporary adverse impacts on wildlife resources as a result of dredged material disposal. Indirect impacts would occur from future port-related developments. A total of 1,000 acres of uplands would be needed to retain the construction material. For planning purposes, the Corps of Engineers identified five potential upland disposal sites, four on Daniel Island and the fifth immediately north of Daniel Island (Figure 3). The five sites total nearly 2,600 acres. Consequently, several combinations of sites would provide the necessary disposal acreage. Table 2 provides the total acreage and the various habitat types found in each site. The predominant vegetative species in each habitat type is denoted in Table 3.

The placement of dredged material on any of the proposed sites would result in similar types of impacts on the land. The future conditions of each site, with the project, would also be similar. Preparation of the sites and disposal of material would result in the destruction of all existing vegetative communities and the dispersion into adjacent areas of wildlife resources dependent on those communities. Even though most wildlife resources within the sites would not be directly destroyed by the disposal operation, their dispersion into adjoining habitats, assuming adjoining areas are at carrying capacity, would result in overpopulation,

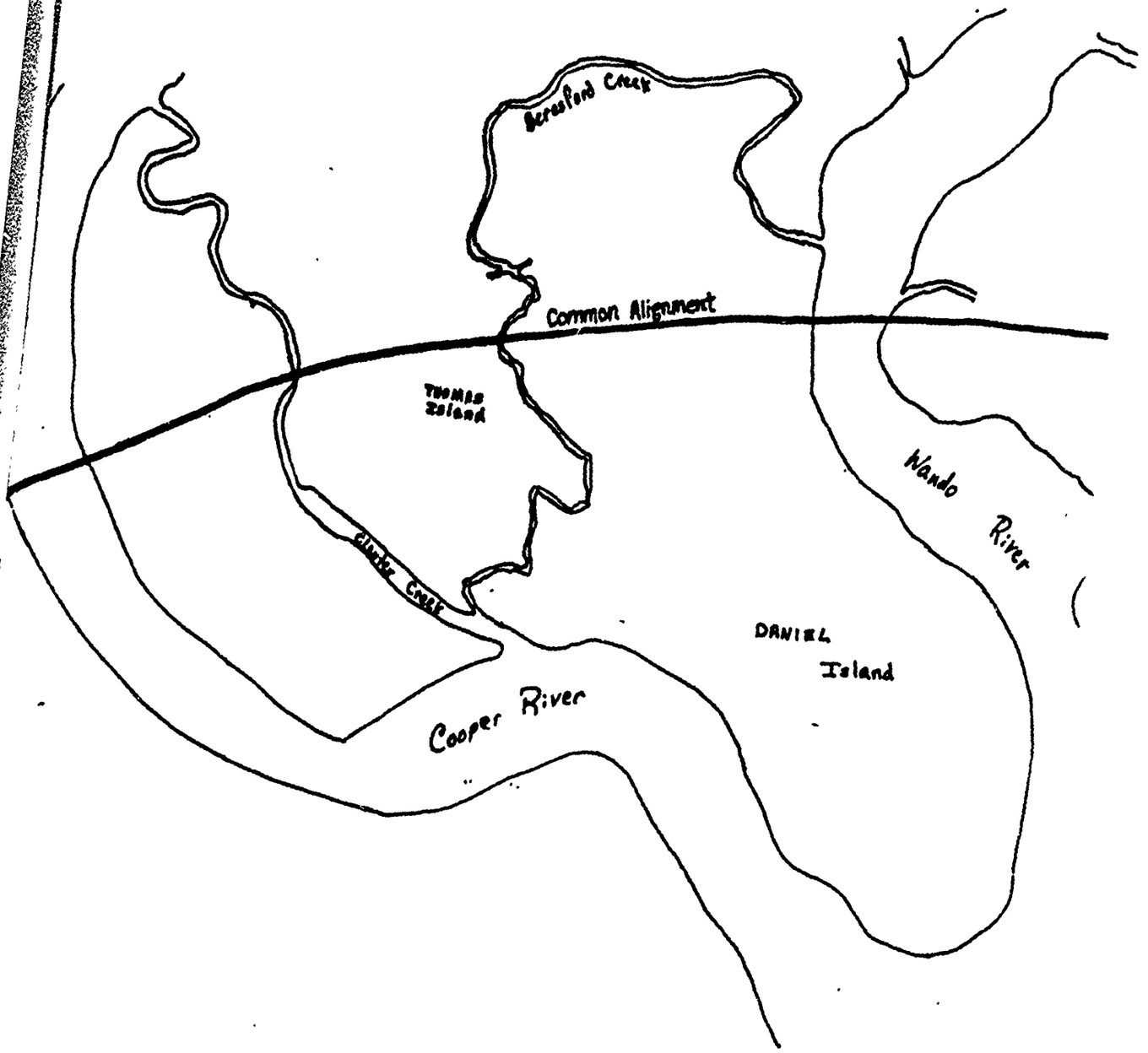


Figure 5. The Mark Clark Expressway's alignment across Daniel Island.

Table 2. The Acreage and Percentage of Habitat Within Each Proposed Disposal Site

Site	Cropland	Forested (Hardwoods/ Pines)	Pasture	Salt marsh	TOTAL
A	215 (54%)	136/37 (44%)		7 (1%)	395
B	149 (16%)	233/37 (30%)	471 (52%)	21 (2%)	911
C		100/128 (100%)			228
D	405 (78%)	96/0 (18%)		20 (4%)	523
E	477 (88%)	65/0 (12%)			542

Table 3. Predominant Vegetative Species by Habitat Types

	Overstory Species	Understory Species
Forested Habitat		
	Water Oak	Wax Myrtle
	Live Oak	Smilax
	Willow Oak	Vaccinium
	Sweetgum	American Beauty Berry
	Blackgum	Chain Fern
	Loblolly Pine	Various Grasses
Salt Marsh Habitat		
	Smooth Cordgrass	
	Black Needlerush	
Cropland Habitat		
	Cucumbers	
	Tomatoes	
	Corn	
	Soybeans	
Pastureland Habitat		
	Various grasses	

and eventual loss. Also, the adjoining wildlife resources would be degraded through overgrazing, disease and other factors resulting from overpopulation. Stable conditions in the adjoining habitats would not be expected for several years after disposal site preparations were completed.

Sites identified as Area "D" and "E" have been tentatively selected to receive the dredged material. Approximately 83 percent of the land in these sites is committed to the production of row crops, principally tomatoes and cucumbers. Consequently, the direct impacts on wildlife resources would be less than if the non-agricultural sites such as "A", "B", or "C" were utilized. Since the existing row crops are of generally low value to wildlife resources and considering the relative short time that the land would be out of crop production (5-7 years), the overall long-term effect of dredged material disposal on wildlife resources is not expected to be detectable. In addition, with the Charleston Harbor Project insuring a continuing competitive harbor and the Mark Clark Expressway providing access, it is anticipated that Daniel Island will experience future port-related industrial development. In fact, the South Carolina Ports Authority has recently identified Daniel Island in their Draft "Port Management Plan" as a port development "opportunity area". The development activities would have similar impacts to those described in the future "without" section of this report. In essence, land use changes resulting from the development would alter the existing habitats, reducing their capacity to support present wildlife populations. Industrial development, in conjunction with other anticipated development, would be expected to occur at a fairly fast rate and the island's wildlife populations would decline proportionally and eventually be lost by the turn of the century.

If construction and all future maintenance material is disposed of in the ocean, direct impacts on wildlife resources would be avoided except for the loss of the 10 acres of tidal marsh resulting from the widening of Shipyard River turning basin.

DISCUSSION

The deepening of Charleston Harbor would basically have minimal direct adverse impacts on the fish and wildlife resources of the project area. However, the widening of a turning basin in Shipyard River would destroy an estimated 10 acres of tidal salt marsh. Modifications in project designs are not available which would mitigate this loss. In the past, the Charleston Harbor Navigation Project has resulted in the destruction of nearly 6,300 acres of tidal marsh. The contributions and values of tidal marsh are well documented and generally recognized throughout the nation.

In the future it can be expected that unavoidable activities that detrimentally impact coastal marshes will continue to take place. However, if nursery grounds for estuarine and marine finfish and shellfish are to be maintained, mitigation or compensation measures must be implemented. Unless appropriate safeguards are taken to conserve the tidal marshes occurring within the project area, the marine and estuarine resources dependent upon these wetlands will be lost.

Consequently, the Service believes that compensation measures must be implemented to offset the loss that will accompany the Charleston Harbor Project's destruction of nearly 10 acres of tidal salt marsh. Compensation should consist of creating 10 acres of tidal salt marsh habitat from an upland (high ground) area. Several potential upland sites exist within the project area. However, the cost estimates provided in Table 4 were based on utilizing an area immediately west of the junction of Beresford Creek and Clouter Creek and near the confluence of Clouter Creek with the Cooper River. The site, formerly a tidal salt marsh, was used once as an unconfined dredged material disposal site during the 1960's.

Marsh creation plans would include grading the area to the same elevation as the tidal marsh adjoining the western border and through sprigging, seeding and natural regeneration be converted to a viable tidal marsh. Studies have indicated that it takes approximately 2 years for a constructed marsh to reach a vegetative density similar to a natural marsh. Consequently, to prevent a loss of productivity as a result of the time lag, marsh construction should be completed 2 years prior to the destruction of the Shipyard River marsh. All costs associated with the marsh creation project should be considered a federal expense and funds provided concurrently with other project construction funds.

The disposal of non-polluted dredged material in an approved ocean disposal site should have relatively minor short and long-term impacts on aquatic resources. If future maintenance material is found to be polluted and exceeds the Environmental Protection Agency's ocean disposal criteria then upland diked disposal would be necessary. The adverse impacts of upland disposal on aquatic resources should be minimal provided that adequate safeguards are taken to prevent dike construction and disposal area outfall waters from affecting wetland habitat.

The use of any one of the five proposed upland disposal sites would result in the displacement of the wildlife resources which inhabit or are dependent on the habitat provided by the site. However, the use of Sites D and E would lessen the direct destruction of wildlife habitat. The project plans indicate that the sites would only be used to retain construction material and not future maintenance material. Consequently, natural succession should commence soon after construction is completed. Since the sites are primarily cropland, conversion to pre-project conditions should occur within two years

Table 4. Marsh Creation Project (Cost Estimate)

Item	Unit	Quantity	Unit Price	Amount
Land	Acre	10	$2,000	$20,000
Earth Moving Equipment (dragline)	cy	16,133[1]	$1.67[2]	$26,900
Marsh Planting	Job	1	lump sum	$20,000
Subtotal				$66,900
Contingencies				$9,000
Engineering and Design				$3,000
Supervision, Administration, and Postconstruction Monitoring				$5,700
Total				$84,600

1. Based on an elevation of +7-feet MSL

2. Based on a dragline cost of $50/hour and the removal of 30 cy/hour

following construction. Through close coordination with the Service and South Carolina Wildlife and Marine Resources Department during Phase II studies some direct short-term impacts associated with the use of these sites could possibly be lessened further.

RECOMMENDATIONS

In order to lessen the project's adverse impacts on fish and wildlife resources and to provide necessary compensation for those losses that cannot be prevented or mitigated, the Service recommends the following:

1. Compensation be provided for the loss of 10 acres of tidal salt marsh. Compensation should consist of creating 10 acres of tidal salt marsh from an upland area adjoining Charleston Harbor. Marsh construction costs estimated at $84,600 should be considered a federal expense and funds provided concurrently with other project construction funds.

2. All construction and future maintenance material dredged from Charleston Harbor, that meets the Environmental Protection Agency's ocean disposal criteria, be placed within an approved ocean disposal site.

3. If ocean disposal of dredged material, construction and/or maintenance is found infeasible, disposal occur within a diked upland (high ground) site.

4. If upland disposal is essential, Daniel Island sites identified as "D" and "E" be used to retain the construction material. During Phase II studies close coordination be maintained between the Service and South Carolina Wildlife and Marine Resources Department in an effort to identify specific wildlife impacts and mitigating measures.

CONCLUSION

Based on existing knowledge and considering the other disposal options available, the placement of suitable dredged material, in an approved ocean site would lessen to the best means possible the impacts of deepening and maintaining the Charleston Harbor Project on fish and wildlife resources.

However, even with ocean disposal of dredged material, the project will result in the loss of fish and wildlife resources. Approximately 10 acres of tidal salt marsh will be destroyed by widening the turning basin in Shipyard River. The President's Executive Orders on floodplains and wetlands and the passage of such legislation as the Coastal Zone Management Act attest to the value of this resource. The Service firmly believes that the tidal marsh destroyed as a result of the proposed federal action, should be compensated for by constructing 10 acres of marsh from an upland site.

If upland disposal of dredged material is necessary, sites "D" and "E" on Daniel Island should be used as the disposal sites. Close coordination should be maintained with the Service and South Carolina Wildlife and Marine Resources Department during Phase II investigations to help insure that the least impacts on wildlife resources occur from the disposal operations.

The Service appreciates the opportunity to provide comments on the Charleston Harbor Deepening Project.

Sincerely yours,

William C. Hickling
Area Manager

Attachments

Literature Cited

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Eldridge, P. T. 1974. The Southeast Shrimp Fishery: Yield. S.C. Mar. Resour. Cent. Tech. Rep. No. 5: 161-169.

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Turner, W. R. and G. N. Johnson. 1974. Standing Crops of Aquatic Organisms in Tidal Streams of the Lower Cooper River System, South Carolina, pp. 13-20. In: F. P. Nelson, Ed. The Cooper River Environmental Study. S.C. Water Resources Comm. State Water Plan Rep. No. 117. Columbia.

Attachment 1

The preliminary draft FWCA report should not have accompanied the Charleston Draft Phase I Report. The FWS submitted the preliminary draft to the Charleston District, as well as to the S.C. Wildlife and Marine Resources Department and the National Marine Fisheries Service for their review and comments. The intentions of the FWS was to "fine tune' its report before it was released as a "Draft". Unfortunately, the Charleston District misinterpreted a "Preliminary" draft report as being a "Draft" ready for circulation and review.

Comments below address each of the issues raised by the Corps concerning the Preliminary FWCA Report. The issues were contained on pages 115-124 of the Corps' December 1979 Draft Phase I Report.

1. The discussion on page 2 of the Preliminary Draft FWCA report was a description of the existing project area, since rediversion is not scheduled to take place until around 1983, it is only discussed under future conditions.

2a. The preliminary report stated "...areas of regularly flooded marsh have been lost due to spoil disposal practices." The Service did not say that "land" was lost, but that the wetlands were filled and consequently lost as a result of past dredged material disposal practices.

2b. Reference to the destruction of wetlands is provided as a general description of the project area. The approximate 100 acres of marsh which were created around Crab Banks and the James Island site of Charleston Harbor were accounted for, however, the total figure is only an estimation and not an absolute. Also, this marsh was created at the expense of productive estuary.

3a. The FWCA report addresses the Phase I study. The alternatives listed in your response were not fully evaluated during Phase I studies since, as stated in page 20 of the Phase I Report, these alternatives "did not meet the study objectives and were eliminated in the preliminary planning stages."

3b. The change was appropriately made.

4a. The FWCA report was revised to indicate that the existing turning basin would be enlarged.

4b. Previous project documents (Final ES, Charleston Harbor Feasibility Report) and personal communication with the Corps' planning staff had indicated that the existing disposal sites could not retain all of the future maintenance material and the material would be placed in the new diked areas. As a result of the Corps' comments on the FWCA report, the Service requested a meeting with Corps staff to clarify the disposal issue.

The meeting was held on January 17, 1980. Information presented at the meeting indicated that the existing 700 acre Daniel Island site would reach capacity by 1988 or 1989. However, based on stacking dredged material 50 feet high, the other existing sites should have capabilities beyond the year 2010. Since the Corps has determined that the existing sites, with the possible exception of Daniel Island, will have the capacity to retain the future maintenance material, the Service has revised its assessment of the impacts that would occur as a result of future maintenance disposal operations.

5. The Service is in agreement with the Corps statement and believes that the FWCA report adequately distinguishes between "with" and "without" project conditions.

6a. Rediversion is appropriately discussed in the future "without project" section of the FWCA report. Rediversion is mentioned in the future "with project" section in regards to the combined effects of channel deepening and reduced freshwater inflow from the Cooper River. The upstream limit of the salt wedge may not be significantly affected by the deepening project; however, the wedge's salinity gradient will be altered by the deepening project.

6b. Your dismissal of our recommendation was apparently based on a 1972 report which prioritized the marshes in Charleston Harbor for use as spoil disposal sites. Individual stands of marshes were ranked on a scale of I to IV, Priority I was considered to have the most overall value. The 69-acre marsh stand in Shipyard River was assigned a Priority IV ranking because the stand is partially bordered by a spoil disposal site and is within an area considered as being heavily industrialized. A Priority IV designation inferred that the area is of relatively little value to fish and wildlife resources. Since 1972, other efforts across the nation have been undertaken to rank various marsh stands. A 1977 study by Oviatt, et al, described an effort to rank various marsh stands by quantitatively sampling each stand. They concluded after comparing sampling results from 10 different stands that little, if any, correlation exists between the visual perception of a marsh and its ecological characteristics. Their quantitative sampling also indicated that even though a marsh is surrounded by development, its ecological value to the estuarine system has not been lost.

The Service maintains that the marsh in Shipyard River, which receives daily tidal inundation and harbors both fish and wildlife resources, must be considered a functional part of the Charleston Harbor estuary. In view of the studies completed since 1972 that further document the values of tidal marshes, and the national recognition and importance placed on the protection and conservation of coastal wetlands, we must insist that the Charleston District protect the Shipyard River marsh or mitigate its loss.

7a. When the preliminary draft FWCA report was submitted, the FWS had not been provided a copy of the benthic study. After reviewing the study results, the Service has revised its comments concerning the impacts of ocean disposal on benthic organisms.

7b. The paragraph has been deleted from the FWCA report.

8. In the preliminary draft report, the Service did not indicate that the Mark Clark Expressway was part of the Charleston Harbor Project. The discussion concerning the Expressway's effects on wildlife resources of Daniel Island occurs in the "future without project" section of the FWCA report. A discussion of the Mark Clark Expressway is also contained in the "future with project" section of the FWCA report because: (a) deepening Charleston Harbor channels will enable the port to remain competitive with other Atlantic coastal ports, and consequently attractive to the siting of new port-related industrial facilities, and (b) the Mark Clark Expressway will provide overland access to Daniel Island, which the S.C. Ports Authority has identified as a port development "opportunity area." Due to the uncertainty concerning when and what type of development may occur on Daniel Island, the Service is unable to separate the impacts that would be specific to the deepening project.

9a. See comment 4b.

9b. Since the submission of the preliminary draft FWCA, sites "D" and "E" have been selected as the disposal sites. The draft FWCA report has been modified accordingly.

9c. The decision to use sites "D" and "E" and the commitment by the Corps that the site would only be used to retain construction material and not future maintenance material greatly reduces the overall adverse impacts on the wildlife resources.

10. Deepening the channels will enable the Charleston port to remain competitive with other Atlantic coast ports. As a result of the port's ability to remain competitive, new port-related facilities will undoubtedly locate within the Charleston area. The S.C. Ports Authority rejected, in part, the Daniel Island site for its new terminal because of the lack of access and the cost of constructing bridge access to the island. The soon-to-be constructed Mark Clark Expressway will provide easy access to the island and the Authority has recently stated in their draft Port Management Plan (March 1979) that Daniel Island represents a port-related development opportunity area.

11. See comment 6b. The FWCA report has been modified to address the concerns which the Corps considers as the "real" problems (where one might acquire high ground adjacent to salt marsh, how could such grading be accomplished, what would one do with the resulting material, etc.) with mitigating the destruction of 10 acres of tidal salt marsh.

12. See previous comments.

13. Due to the reduced impacts that will occur from the use of sites "D" and "E", the Service does not believe that a formal mitigation plan is warranted provided that close coordination be maintained between the FWS and SCWMRD during Phase II studies. Close coordination will enable the FWS and SCWMRD to suggest changes such as dike alignments, etc., which could further mitigate any adverse impacts.

14. See previous comments.

15a. The Service recognizes that the recommendations have been a part of the Corps plan since the pre-1976 survey stage.

15b. The Service's recommendations have been altered accordingly. See previous comments.

15c. The Service's recommendations concerning secondary impacts have been removed.

15d. See previous comments and draft FWCA Report.

16. See previous comments and draft FWCA Report.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Duval Building
9450 Koger Boulevard
St. Petersburg, FL 33702

August 23, 1979 FSE61/RPC

Mr. William Hickling
Area Manager
USDOI, FWS
Asheville Area Office
Room 279, Federal Building
Asheville, NC 28802

Dear Mr. Hickling:

As requested in your recent letter, we have reviewed the Preliminary Draft Fish and Wildlife Coordination Act Report for the Corps of Engineers proposal to deepen the existing navigation channels in Charleston Harbor, South Carolina.

We concur in your assessment and the mitigation needed if the project is constructed as proposed.

We appreciate the opportunity to review the draft report.

Sincerely yours,

William H. Stevenson
Regional Director

South Carolina
Wildlife & Marine
Resources Department

12 SEP 1979

James A. Timmerman, Jr Ph D.
Executive Director

September 7, 1979

Mr. William Hickling, Area Manager
Fish and Wildlife Service
Asheville Area Office
Room 279, Federal Building
Asheville, North Carolina 28802

Dear Bill:

Personnel of the South Carolina Wildlife and Marine Resources Department have reviewed the draft Fish and Wildlife Coordination Act report regarding the proposed deepening of the existing navigation channels in Charleston Harbor, South Carolina. We concur in the report findings and recommendations.

Sincerely,

James A. Timmerman, Jr.
Executive Director

JATjr:cs

bcc: Roger Banks

P O Box 167 ☐ Dutch Plaza ☐ Building D ☐ Columbia, South Carolina 29202 ☐ Telephone 803-758-6536

Response to the U. S. Fish and Wildlife Service

General. Descriptions of the existing environmental conditions in the FWCA report are generally accurate, but the report stresses the few unavoidable adverse impacts of the project and appears to have consciously excluded any reference to benefical impacts or the extended twelve-year research and coordination effort undertaken to minimize the effects on natural resources. Filling in wetlands, both in the "Description of Project Area" and "Discussion" sections, is particularly overemphasized. Since the early planning efforts, the Charleston District has made it clear that material dredged during the deepening of the harbor would not be placed in the remaining valuable wetlands. The "Preliminary Draft FWCA Report" was the only FWS report available at the time the draft Phase I report was circulated, although the deadline had been extended. If preliminary FWS reports are not suitable for circulation and review, they should not be circulated among other agencies by the FWS with the errors uncorrected.

Specific Comments, Keyed to the Numbered Comments in Attachment 1 and the Page Number of the FWCA Report.

1., Page 3, second paragraph. The 1944 diversion project was carried out by the South Carolina Public Services Authority. The rediversion by the Corps of Engineers will return approximately 80% of the upper Santee basin waters back into the Santee River. The present source of Cooper River flow is important in understanding both the existing shoaling problem and the changes in shoaling and freshwater flow that will occur when rediversion is accomplished.

2., Page 3, fourth paragraph. The final version of the FWCA report still permits the erroneous impression that wetlands are routinely being used as disposal areas and fails to mention instances, such as Drum Island, in which disposal has created unique wildlife habitat or prime farmlands. A statement can be misleading without being strictly inaccurate. A description of past dredging practices and potential impacts should include the fact that neither the existing project nor the proposed deepening will include disposal in the valuable wetlands that remain.

Page 4, paragraphs 1-3. The figures on capacities of the existing diked disposal areas were updated during a 10 January 1980 meeting with FWS but are not reflected in this portion of the FWCA report. Minutes of the meeting are attached to these comments.

3., Page 4, fourth paragraph. Alternatives to channel deepening, such as a lighterage system, an offshore ocean terminal, a terminal at Cummings Point, light loading, and pipelines, were reviewed in the Phase I study to see if there were any changes in shipping methods or quantities that would justify further study of these alternatives that had been eliminated in the early planning stages. There were no such changes.

4., Page 6, last paragraph. There is very little possibility that any maintenance material, even from the channels near Daniel Island, might be placed in the same upland disposal areas used during initial deepening. See the minutes of the 10 January 1980 meeting with FWS, attached to these comments.

5., Pages 8 and 9. Under the heading "FISHERIES RESOURCES", the description of conditions without deepening fails to note that annual dredging of the existing project now occurs and will continue to disturb invertebrates on the channel bottom, even if the deepening study were terminated.

6.a, Page 10, first paragraph. Although somewhat clarified by the FWS comments in Attachment 1 to the FWCA report, this paragraph remains confusing because it is not clear whether the last sentence refers to the major changes in freshwater flow caused by the rediversion project or the small upstream movement of the saltwater wedge due to deepening in the lower Cooper River.

6.b, Page 10, second paragraph. See the response to the S. C. Wildlife Federation on page E-3 of this appendix. The 1972 "Study of the Charleston Harbor Estuary, With Special Reference to Deposition of Dredged Sediments", was conducted by the S. C. Wildlife and Marine Resources Department under contract to the Charleston District and was reviewed by the FWS as part of

the early planning effort. The study "was designed to delineate those marshlands which are of lesser importance to wildlife and fisheries with minimal damage incurred at the producer-consumer and/or habitat levels of the ecosystem". Priority IV wetlands were characterized as having "little value to fisheries and wildlife resources" and "unrealistic to manage". The 1972 report provides the basis on which the four priorities were designated. It is misleading to indicate that the preponderance of recent research does not discriminate between types of marsh in terms of productivity or function. A wide range of productivity and function has been noted in the literature since 1972, based on vegetation, location, flushing characteristics and other factors. The Priority IV wetlands near Shipyard River have some residual value; however, no effort has been made in the FWCA report to describe the functions of these wetlands in a manner that would explain the wide variation between the 1980 FWCA report, the 1972 SCWMRD report, and FWS's 1974 review of the 1972 report, or to serve as a basis for mitigating the impacts to these altered wetlands.

7., Page 10, third paragraph. The 1972 SCWMRD report on Charleston Harbor included the statement that an increase in finer materials "could result in the enhancement of adjacent areas by creating habitat for valuable species such as Penaeid shrimp. This in turn would generate potential for increased or, at least more productive commerical fisheries". Disposal of predominantly sandy material from the entrance channel, which includes some pockets of fine grained silt, has caused no significant impact on bottom type or benthic community structure. No absolute conclusions can now be drawn as to the exact impact of disposal of finer material or its ultimate location after dispersion; however, previous studies indicate that even the heavier particles are quickly spread by tidal action and ocean currents. A great deal of effort has been made to predict the physical, chemical and biological impacts of disposal through the benthic studies, bioassays, bioaccumulation studies, and sediment and liquid phase analyses of material to be dumped. EPA has conducted additional studies on the disposal site and is expected to provide final approval of the site in 1980. The material from the entrance channel and inner harbor has been found suitable for ocean disposal according to EPA regulations. The discussion of the probable impacts of ocean dumping in the FWCA report should at least acknowledge the above studies

and the lack of impact due to previous disposal of material from the entrance channel. Further information on current patterns will be gathered prior to construction, and a monitoring program will follow the effect, if any, on the substrate, water quality, and benthic organisms in the ocean dump site and surrounding area.

7.b, 8 and 10, Page 14, second paragraph, and Page 18, second paragraph. It is not clear why the FWS believes that changes on Daniel Island, with the Mark Clark Expressway and existing 35-foot channel, would be limited to a gradual increase in only residential and commercial development. Rapid port-related industrial development, on the other hand, is ascribed to the deepening of the harbor. In either case, with or without the deeper channel, it is clear that construction of the expressway is the causative factor that permits development of Daniel Island for commercial, residential, and industrial purposes. Separation of the factors causing changes in an area is a routine procedure employed in the NEPA process in order to assign the responsibility for assessing impacts, prevention of unnecessary damage, and mitigation. The Corps recognizes the high quality of habitat in wooded uplands on Daniel Island and has taken great care in its project planning to avoid permanent or unnecessary impacts.

11., Pages 18 and 19. See comments to the S. C. Wildlife Federation (re: Shipyard River) on page E5 of this Appendix.

SACEN-E

25 February 1980
MORRISON/614/fh

MEMORANDUM FOR RECORD

SUBJECT: Meeting with the U. S. Fish and Wildlife Service on the Charleston Harbor Deepening (Phase I) Study and Other Projects Requiring Disposal of Material Dredged from Charleston Harbor

a. Date of meeting: 10 January 1980

b. Place: Charleston District Office

c. Purpose: To discuss with FWS the plans for disposal of material from Charleston Harbor, in order that FWS can complete its actions under the Fish and Wildlife Coordination Act.

d. Persons attending:

Doug Winford, Charleston Office, FWS
Larry Casbeer, Planning Branch, Charleston District
Braxton Kyzer, Survey Branch, Charleston District
Steve Morrison, Environmental Resources Branch, Charleston District

e. Background: Ocean dumping now appears to be the preferred method for disposal of most of the material to be dredged during the proposed deepening of Charleston Harbor from 35' to 40' and for the material to be dredged from the Wando Channel. However, the possibility that the equipment needed to implement ocean dumping will not be available at the time of initial deepening makes it impossible to state positively that ocean dumping will be employed for the inner harbor. Accordingly, the Phase I report for the deepening project discussed both ocean disposal and the use of diked areas (existing and new) for inner harbor material. In order to complete the NEPA process and the coordination with other agencies (including FWS), the Charleston District was instructed to pick out specific upland disposal areas for inner harbor material and to evaluate them fully, even though the availability of these sites at construction time could not be guaranteed. It was felt that this was the only disposal method that the Corps could definitely say was available and that evaluation of the upland sites would cover the "worst case". For this purpose, the following assumptions were made in the Supplemental Information portion of the Phase I report: (1) Entrance channel material would go to offshore disposal areas; (2) material from the initial inner harbor deepening work would go to new upland sites; and (3) material from maintenance of the deeper inner channel would be placed in existing diked disposal areas. The Supplemental Information Report clearly stated, however, that ocean dumping was the preferred method, and an evaluation of the ocean dump site and the tests for suitability of material for dumping were also included in the report.

There are two other "projects", one in existence and one being studied, which would require disposal of material from Charleston Harbor: Charleston Harbor O&M (35' project) and the Wando Channel study. The FWS was confused by the various separate reports, portions of which have been outdated by new disposal techniques, new projects using the same disposal areas, and recent plans by the SPA to acquire new easements. Mr. Winford requested a meeting to clarify the quantities of material and the locations of the disposal areas to be used for the projects.

SACEN-E 25 February 1980

SUBJECT: Meeting with the U. S. Fish and Wildlife Service on the Charleston Harbor Deepening (Phase I) Study and Other Projects Requiring Disposal of Material Dredged from Charleston Harbor

f. Summary of meeting:

(1) Mr. Winford stated that the FWS preferred the use of ocean disposal for inner harbor material to the use of new disposal areas on uplands or in wetlands, provided that the material was suitable for ocean disposal.

(2) Mr. Winford asked for a clarification on the possible use of upland sites on Daniel Island (assuming that ocean disposal is not possible at the time of construction). (a) The first question dealt with the possible use of the same upland areas for original construction of the deepening project and for the Wando Channel. The Phase I Supplemental Information Report stated that, if the use of upland sites was necessary, the upland sites would be used only for the initial deepening of the inner harbor, and that maintenance material would be put in existing diked areas. This would allow the upland sites to revert back to croplands in about five years. Mr. Winford noted that if materials from the Wando Channel were later put in this same area, it would prevent recovery of the areas as described in the Phase I document. In reply, Mr. Casbeer stated that, in the Phase I report for deepening the main channel, we could not even assume that the Wando Channel would be dredged by the Corps. The inclusion of the Wando Channel as a Corps project is merely a study at this time. Ifthe SPA dredges it as described in their permit, the material would go to Morris Island. If the Corps does dredge it, the material would most probably go to an ocean disposal site, or possibly to an upland site not on Daniel Island. Wherever the material from the Wando is placed, the impacts would have to be evaluated in the reports describing the Wando project, and any costs for mitigation of these impacts would have to be a part of that project. The possibility that Wando River material would be put in the same Daniel Island disposal area and would prevent growth of crops and return of wildlife for an additional period of time cannot be attributed to the harbor deepening, and, because of the improbability that it would occur at all, it cannot be considered as a given condition (like rediversion) outside the scope of the Phase I study. (b) The second question about Daniel Island concerned the possible use of the same upland sites for the initial construction of the deeper channel and for the additional material to be dredged in the maintenance of the deeper channel. Mr. Kyzer expalined that, in the upper reaches of the channel, the Clouter Creek disposal area could handle all maintenance material far in excess of 30 years. Similarly, in the lower harbor, Morris Island could handle maintenance material in excess of 30 years, even if Wando Channel and anchorage basin materials were also placed in it. The only reach where there is not a surplus of available areas is the middle harbor. The currently used diked area on the tip of Daniel Island will last for approximately 10 years at existing rates of disposal and if SPA also extends its easement on Drum Island as planned. After 10 years, a new disposal area would have to be sought, regardless of any deepening in this reach. The additional maintenance dredging due to deepening would require going to a new area approximately one year sooner. Note, however, that this 10-year life is based upon the shoaling rates remaining the same and the shoals continuing to occur in the same locations. With rediversion of water back into the Santee River, the shoaling rates should decrease by 1990. In addition, the location of the heaviest shoaling, now in the middle reach, is expected to move upstream to the area where disposal capacity is greatest. With a reduction in shoaling rates and movement of the heaviest shoaling upstream, even maintenance in the middle reach could be handled by existing areas for over 10 years. Ocean dumping

SACEN-E 25 February 1980

SUBJECT: Meeting with the U. S. Fish and Wildlife Service on the Charleston Harbor Deepening (Phase I) Study and Other Projects Requiring Disposal of Material Dredged from Charleston Harbor

of inner harbor material may be possible by 1985 (the time of the deepening). Recent information indicates that its use by 1985 is much more promising than at the time the Phase I report was written. It will almost certainly be available by 1990. Therefore, there is very little chance that maintenance material would be placed on upland Daniel Island sites.

(3) Mr. Winford asked if costs and an assessment of feasibility could be developed for the pumping of material from existing diked areas to ocean sites, thus allowing reuse of the existing diked areas. A discussion of this method and comparison with other methods was included in a 1968 Charleston District study on long-term disposal plans. Mr. Winford would like to see the revised costs and feasibility addressed in the Phase I or Phase II report. Mr. Casbeer agreed to make the updated information available to the FWS.

(4) In another matter related to the Charleston Harbor Deepening project, Mr. Winford stated that the FWS would continue to ask for mitigation for the use of lands excavated in the widening of the turning basin in Shipyard Creek, even though the wetlands had been described as belonging to the lowest category of wetlands by the S. C. Wildlife and Marine Resources Department and having little value for fish and wildlife. Mr. Windford states that, although its potential use by fish and wildlife was reduced, the highly altered area still has some residual value. Mr. Morrison pointed out that Executive Order 11990 does not prohibit work in all wet areas, but requires, first, that there be no other practicable location and, secondly, that the work be done in a manner that will hold the disturbance to a minimum. The work proposed in Shipyard Creek meets both of these requirements. Even more pertinent are the portions of the Executive Order that describe the types of wetland functions that the order attempts to protect. The poor quality of the area, previous disruption, industrial nature of land use and lack of management potential indicate that the conversion of this small area to open water would not be a significant loss and does not justify large expenditures or disruption of surrounding areas in an attempt to create new marsh. Mr. Morrison agreed to re-examine the area, and Mr. Winford agreed to re-examine the regulations applicable to wetlands.

Stephen J. Morrison

STEPHEN J. MORRISON

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION IV

345 COURTLAND STREET
ATLANTA, GEORGIA 30308

February 5, 1980

4SA-EIS

Colonel William W. Brown, USA
Corps of Engineers, Charleston District
P. O. Box 919
Charleston, South Carolina 29420

Dear Colonel Brown:

We have reviewed the Draft Phase I Report, Charleston Harbor, Deepening and Extending Channels for Navigation and make these observations:

Most large harbors in Region IV, e.g., Wilmington, Georgetown, Savannah, Jacksonville, etc., have dredge disposal problems. Given the apparently reality that these facilities will continue to expand, either additional satisfactory upland sites must be found or ocean disposal must be used.

We have consistently recommended ocean disposal for the Charleston Harbor project because it does not adversely impact valuable wetlands, degrade fish and wildlife resources, or diminish the quality of ground or surface water supplies. It would allow the existing spoil sites to be saved/reserved for maintenance spoil disposal and ocean disposal can be done at a reasonable cost with properly designed equipment. This report states (Page 60) that ocean disposal cannot be presently implemented because the special dredge needed to pump the dredged material onto hopper barges for transportation to ocean sites is not available. We presume that the equipment referred to in Plan 4 (Cooper River-Ocean Disposal) is similar to that outlined under Plan 8 of the Long-Range Spoil Disposal Study for Charleston Harbor dated July 1970. This equipment included a dredge with a specially designed pump which could be mounted at the bottom of the dredging arm near the drag head so as to increase the percent of solids in the discharge to the barge. Thus, the number of trips to the ocean disposal site would be reduced. The system also included dual swiveled pipes for loading the barges, i.e., one barge could be loaded while the other was moving into loading position. With sufficient barges the dredge could run continuously. The 1970 report (Plan 8) estimated three pairs of barges and two tows would be necessary. Bottom unloading barges would be preferred for this operation, but would not be necessary if pumpout facilities were provided. The barges and tugs for towing should not be a problem since they are made and used extensively in this country.

Although the ladder pump may not have been used commercially in the United States at the time the 1970 report was written, recent investigation indicates that several companies now use this equipment to increase the efficiency of their operations. The C. F. Bean Company of New Orleans, the Great Lakes Dredging and Dock Company of Chicago, and the Williamette Western Company of Portland, Oregon, have equipped some of their dredges with underwater ladder pumps. These pumps have been used in most cases in tandem with the existing dredge pump to increase the distance the dredge can pump and to increase the efficiency of the operation. It seems reasonable to assume that such a ladder pump could be used by itself to deliver a high solids effluent to barges. In fact, such a system is proposed for the Mobile Harbor project. The barges should be equipped with overflow chambers so that when sandy materials are being handled, full advantage can be taken of the settleability of the materials. Recent improvement has also been made in the overflow devices.

Because long haul ocean disposal of large quantities of dredged material has not been required, no dredging contractor presently has such a system. However, there is no reason why such a system could not be assembled from available equipment if the contractors were given adequate time. We contend that the 1985-1986 date for the start of construction (Page 60) is adequate time provided contractors are notified in advance.

Since the report considers that equipment is not available for ocean disposal of the material to be taken from the interior channels, five upland sites have been selected on Daniel Island as possible disposal sites. Of the five new proposed upland sites, Site E, 542 acres and Site D, 523 acres would have sufficient size to meet new work material disposal needs. While they would have the least adverse effects on the environment, they would involve the use of considerable prime farmland, woodlands and wetlands. Sites A and B have exceptional wildlife value while Site C is entirely wooded and also has good wildlife value.

The construction of the upper turning basin in the Shipyard River area will consume 10 acres of wetlands which the U. S. Fish and Wildlife Service considers valuable enough to request mitigation. We support this view and look forward to the finalized plan on this matter.

Regardless of the measures taken, valuable cropland, forest areas and wetlands will be consumed by the project if upland disposal is used; additional areas will then be required for maintenance because some of the existing sites are nearing full capacity. The proposed upland spoil sites will impinge on wildlife areas of exceptional value; therefore, every effort should be made to remove the obstacles to ocean disposal.

If the equipment were assembled for the Charleston Harbor project, it could readily be used to advantage at the other harbors for new work and maintenance operations.

If we can be of further assistance, feel free to call on us.

Sincerely yours,

Sheppard N. Moore

Sheppard N. Moore
Chief, EIS Review Section

Response to U. S. Environmental Protection Agency

See the response to the South Carolina Wildlife Federation letter on page E-3 of this report. The response addresses both ocean dumping and the wetlands adjacent to Shipyard River.

UNITED STATES DEPARTMENT OF COMMERCE
The Assistant Secretary for Science and Technology
Washington, D.C. 20230
(202) 377-XXXX 4335

February 20, 1980

Colonel William W. Brown
Department of the Army
Charleston District, Corps of Engineers
P.O. Box 919
Charleston, South Carolina 29402

Dear Colonel Brown:

This is in reference to your draft Environmental Impact Statement entitled, "Charleston Harbor, South Carolina." The enclosed comments from the National Oceanic and Atmospheric Administration are forwarded for your consideration.

Thank you for giving us an opportunity to provide these comments, which we hope will be of assistance to you. We would appreciate receiving seven copies of the final statement.

Sincerely,

Sidney R. Galler

Sidney R. Galler
Deputy Assistant Secretary
for Environmental Affairs

Enclosures: Memorandums from:
NOAA-Environmental Data and Information Service-K. Hadeen
NOAA-National Ocean Survey-Robert B. Rollins

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
ENVIRONMENTAL DATA AND INFORMATION SERVICE
Washington, D.C. 20235
Center for Environmental Assessment Services

Rec'd PP/EC
22 JAN 1980

January 17, 1980 OA/D23/ELR

TO: PP/EC - R. Lehman

FROM: OA/D2x1 - K. Hadeen

SUBJECT: DEIS 8001.05 - Charleston Harbor, South Carolina Deepening and Extending Channels for Navigation

Little effort has been devoted to a description of the physics of the environment and consequently the resulting harbor circulation is not well defined in the subject document. The potential impact of projected increase in petroleum products passing through the harbor should be examined. Table B.6 of Appendix A indicates a doubling of such products by the year 2005. Should an accident occur within the harbor complex, the resulting impact on the estuarine and marsh ecosystems could be quite severe.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SURVEY
Rockville, Md. 20852

OA/C52x6:JLR

FEB 1980

Rec'd PP/EC
07 FEB 1980

TO: PP - Joyce M. Wood

FROM: OA/C5 - Robert B. Rollins

SUBJECT: DEIS #8001.05 - Charleston Harbor, South Carolina, Deepening and Extending Channels for Navigation

The subject statement has been reviewed within the areas of the National Ocean Survey's (NOS) responsibility and expertise, and in terms of the impact of the proposed action on NOS activities and projects.

Considerably more tide information can be obtained from the Tide Tables, East Coast of North and South America including Greenland, National Ocean Survey, National Oceanic and Atmospheric Administration (NOS, NOAA), Annual, and/or by writing directly to the Chief, Tides and Water Levels Division (OA/C23), Office of Oceanography, NOS, NOAA, Rockville, Maryland 20852 (phone 301-443-8254).

Current measurement documentation is completely absent from the statement. Channel currents may be obtained from the Tidal Current Tables, Atlantic Coast of North America, NOS, NOAA, Annual. Physical oceanographic information for the offshore dump site area appears to be limited to sediment characteristics and biological oceanography.

A literature search for current data in the dump site area should be made. If none are available, measurements should be conducted. The Marine Environmental Services Division, Office of Oceanography, NOS, NOAA, can assist in the search for existing data. Please contact the Chief, Circulatory Surveys Branch (OA/C211), Marine Environmental Services Division, Office of Oceanography, NOS, NOAA, Rockville, Maryland 20852 (phone 301-443-3501), if desired.

Response to U. S. Department of Commerce
National Oceanic and Atmospheric Administration

1. The harbor and a variety of channel locations and depths were physically modeled to determine circulation and shoaling patterns.

2. A literature search and the services of NOAA will be used in the upcoming study to better define currents and the probable movement of material from the ocean disposal site.

State of South Carolina

Office of the Governor

RICHARD W. RILEY
GOVERNOR

POST OFFICE BOX 11450
COLUMBIA 29211

February 19, 1980

Colonel William W. Brown
U.S. Army Corps of Engineers
Post Office Box 919
Charleston, South Carolina 29402

Dear Colonel Brown:

This responds to your 26 December 1979 letter, requesting the views of the State of South Carolina regarding President Carter's proposed cost-sharing policy. The specific subject concerns the Charleston Harbor Deepening Project at the Port of Charleston.

In view of present uncertainties regarding Congressional action on President Carter's proposals, I feel that it would be premature for the State of South Carolina to declare a position. I do know, however, that the State Ports Authority, as well as the American Association of Port Authorities, is firmly opposed to the application of the proposed cost-sharing formula to navigation channels. I am also aware that the State of Georgia, through Governor George Busbee, has also expressed opposition.

The State of South Carolina is in firm support of the Charleston Harbor Deepening Project as an absolute need for the state and region's economy. We intend to take every required step to provide appropriate sponsorship. Our financial support has been already widened through the extensive investment of state capital in existing and expanding public terminal facilities in Charleston.

If and when the President's cost-sharing proposals become law, we will then take the matter of an investment in the total project outlay under more active consideration.

Yours sincerely,

Richard W. Riley

Richard W. Riley

RWR/mbf

COMMANDER NAVAL BASE
CHARLESTON, S. C. 29408

Code N3
Ser 075
28 FEB 1980

From: Commander, Naval Base, Charleston, SC
To: District Engineer, Charleston District Corps of Engineers, Charleston, SC

Subj: Deepening and Extending Channels of Charleston Harbor for Navigation Study

Ref: (a) Charleston District Corps of Engineers ltr SACEN-PS of 28 Dec 1979

1. As requested by reference (a), the subject study was reviewed by this Command and comments are hereby submitted.

2. The proposed improvements are considered beneficial to Navy interests in Charleston.

3. The number of Navy ships homeported in Charleston is expected to increase by over thirty per cent by 1986. This will result in a proportionate increase in Navy activity in the Charleston Harbor.

4. The size of the Navy ships homeported in Charleston is also increasing. The Cooper River channel along the Naval Station piers (Clouter Creek Reach) is six hundred feet wide. The study indicates deepening the channel to 40 feet in Clouter Creek Reach. It would be beneficial to the Navy if the channel could also be widened to the north by an additional 100 feet, for a resultant width of 700 feet, in the Clouter Creek Reach area between Navy piers G and R. This would provide a wider and safer navigational channel for the newer Navy ships that are over 500 feet in length to maneuver in and out of the Navy piers. The depth of this additional northern 100 feet of channel should be maintained at 35 feet.

5. References to Naval Ammunition Depot (NAD) in the study should be changed to Naval Weapons Station (WPNSTA).

W. K. PEERY
By direction

Copy to:
COMNAVSHIPYD CHASN
CO SOUTHNAVFACENGCOM
CO NAVSTA CHASN

DEPARTMENT OF THE ARMY
CHARLESTON DISTRICT, CORPS OF ENGINEERS
P.O. BOX 919
CHARLESTON, SOUTH CAROLINA 29402

SACEN-PS 27 March 1980

SUBJECT: Deepening and Extending Channels of Charleston Harbor for Navigation Study

Commander
Naval Base
Charleston, S. C. 29408

Re: Code N3 Ser 0475

1. This is in reply to your letter of 28 February 1980, which recommends the widening of Clouter Creek reach to 700 feet to meet the future needs of the Navy.

2. Widening of the subject reach cannot be justified on the basis of commercial navigation. Therefore, it cannot be included in the proposed deepening project. However, we can widen and deepen the area, at the Navy's expense, at anytime you consider it necessary and can furnish the required funds.

3. I appreciate your comments, and all references to the Naval Ammunition Depot (NAD) have been changed to Naval Weapons Station (WPNSTA).

WILLIAM W. BROWN
Colonel, Corps of Engineers
District Engineer

south carolina state ports authority
CHARLESTON / GEORGETOWN / PORT ROYAL / PIEDMONT
P O BOX 817, CHARLESTON, SOUTH CAROLINA 29402, TELEPHONE 803 723 8651

March 31, 1980

W. DON WELCH
EXECUTIVE DIRECTOR

Colonel W. W. Brown, District Engineer
U. S. Army Corps of Engineers
Post Office Box 919
Charleston, South Carolina 29402

Dear Colonel Brown:

This letter is in reference to your letters of March 25, 1980 and December 26, 1979, concerning the conditions of local sponsorship for the Charleston Harbor Deepening Project.

The South Carolina State Ports Authority will provide the items of local cooperation as outlined and amended in these two letters. In providing assurance that we will furnish these items, we also wish to make a formal statement of our objection to the Corps' inclusion of a 5% cost share from the State of South Carolina on this project. As we stated in our comments at the public hearing, this proposed cost sharing does not have legal authority. The State Ports Authority would contest any attempt by the Corps of Engineers to include cost sharing without a legislative basis.

Sincerely,

W. Don Welch

WDW:rl

SACEN-PS 25 March 1980

Mr. Don Welch
Executive Director
South Carolina State Ports Authority
P.O. Box 817
Charleston, SC 29402

Dear Mr. Welch:

This is in reply to your letter of 15 February 1980 concerning requested changes in the items of local cooperation, contained in the Phase I AE&D study on Charleston Harbor, to reflect ocean disposal of dredged material.

This matter has been discussed with our higher authority and it was concluded that item (a) of the items of local cooperation furnished in our letter of 26 December 1979 should be revised as follows:

a. Provide without cost to the United States all lands, easements, and rights-of-way required for construction and subsequent maintenance of the selected or interim plans of improvement and for aids to navigation upon the request of the Chief of Engineers as may be required in the general public interests for initial and subsequent disposal of dredged material, as well as the necessary retaining dikes, bulkheads, and embankments or the costs of such works, all at a presently estimated total non-Federal first cost of $9,637,000. At the time of construction, consideration will be given to implementing ocean disposal of dredged material. If ocean disposal proves to be practical from the points of view of environmental protection, cost, and availability of equipment, local costs for the initial construction work would be significantly reduced.

All other items of local cooperation would remain the same.

Our final report cannot be submitted until your letter agreeing to furnish the items of local cooperation has been received. Therefore, I would appreciate expeditious action on this matter, and if you have any questions please give me a call.

Sincerely,

WILLIAM W. BROWN
Colonel, Corps of Engineers
District Engineer 25 MAR

south carolina state ports authority
P O BOX 817 CHARLESTON SOUTH CAROLINA 29402 TELEPHONE 803 723-8651

February 15, 1980

Colonel W. W. Brown, District Engineer
U. S. Army Corps of Engineers
Post Office Box 919
Charleston, South Carolina 29402

Dear Colonel Brown:

I am writing in reference to your December 26, 1979 letter. In that letter you forwarded to us the draft Phase I AE&D Report on Charleston Harbor, South Carolina. Your letter also outlined the items of local cooperation described in the recommendations of the report and asked us to furnish to you assurances that the Authority will provide these items.

Since that time, you have changed the recommendations of the report, specifically in regards to the disposal of material from the project. These changes create significant alteration in the items of local cooperation, especially Item (a). Would you please send us a revised letter reflecting your current recommendations so that our reply can be responsive to the current project status.

Sincerely,

W. Don Welch
Executive Director

WDW:rl

SACEN-PS 26 December 1979

Mr. Don Welch
Executive Director
South Carolina State Ports
Authority
P. O. Box 817
Charleston, S. C. 29402

Dear Mr. Welch:

Inclosed for your review and comment is a copy of the draft Phase I AE&D Report on Charleston Harbor, South Carolina. The Phase I report recommends deepening, along with some basin and channel widening of the existing Charleston Harbor and Shipyard River Federal navigation projects to 40 feet and 38 feet, respectively.

As local sponsor of the project, you are requested to furnish additional assurances at this time that the South Carolina State Ports Authority will provide the items of local cooperation described in the recommendations of the report. These items of local cooperation are as follows:

a. Provide without cost to the United States all lands, easements, and rights-of-way required for construction and subsequent maintenance of the selected or interim plans of improvement and for aids to navigation upon the request of the Chief of Engineers, including suitable areas determined by the Chief of Engineers, to be required in the general public interests for initial and subsequent disposal of dredged material, as well as the necessary retaining dikes, bulkheads, and embankments or the costs of such works, all at a presently estimated total non-Federal first cost of $9,637,000. The exact amount of Federal and non-Federal contributions shall be determined by the Chief of Engineers prior to project construction, in accordance with the local cooperation requirements.

b. Hold and save the United States free from damages that may result from the construction and maintenance of the project, except damages due to the fault or negligence of the United States or its contractors.

c. Provide and maintain without cost to the United States adequate public terminal and transfer facilities open to all on equal terms.

SACEN-PS
Mr. Don Welch

26 December 1979

d. Provide and maintain without cost to the United States depths in berthing areas and local access channels serving the terminals commensurate with the depths provided in the related project areas.

e. Accomplish without cost to the United States all alterations and relocations of buildings, transportation facilities, storm drains, utilities, and other structures and improvements made necessary by the construction.

f. Prohibit the erection of structures within 125 feet of the bottom edge of the recommended Federal project channels or turning basins.

In addition to the above, the State of South Carolina will be required to make a cash contribution equal to 5% of the first costs of construction of the project, presently estimated at $2,859,000.

If you wish to comment on any portion of this report, your comments, as well as your letter agreeing to the items of local cooperation listed above, should be sent to this office no later than 8 February 1980. A final report will be prepared by this office following the receipt of comments from Federal, State and local agencies and interested individuals.

Sincerely,

1 Incl
As stated

WILLIAM W. BROWN
Colonel, Corps of Engineers
District Engineer

CASBEER/374/lz
DELAY/EN-PS
MEREDITH/EN-P
LESEMANN/EN
BROWN/DE